The History
of
Combat Airplanes

CHARLES G. GREY

A
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NORWICH UNIVERSITY
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Combat Airplanes

By

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U. S. A.

The James Jackson Cabot Professorship of Air Traffic Regulation and Air Transportation of Norwich University was endowed in 1935 by Dr. Godfrey Lowell Cabot, of Boston, Massachusetts, and named in memory of his son, James Jackson Cabot, an officer in the U. S. Flying Service during the World War.

Following its custom of producing and distributing publications treating of aviation developments and trends, on February 3, 1941 the James Jackson Cabot Professorship wrote Mr. Charles G. Grey, inviting him to prepare a history of combat airplanes. Mr. Grey, who for more than twenty-eight years was editor of *The Aeroplane,* not only has been one of England's best informed men on aviation over a long period of years, but is well acquainted with aircraft history and development in Europe and the United States.

It was realized that war conditions and censorship would necessarily exert their limiting influence. Indeed, the former had an immediate and direct influence, for Mr. Grey twice was bombed out of his quarters while he was preparing his material. The first section of his typescript was received in June, and from then until a few weeks ago succeeding installments came to us.

The following is the final result of his work. It is believed that it will be not only of current interest but of historical importance because of the wealth of Mr. Grey's contacts and experience. I personally found his mention of many old friends and machines of exciting interest, and his comments on American aircraft of real encouragement.

Porter Adams

Chairman, Administrative Committee.

NORWICH UNIVERSITY
NORTHFIELD, VERMONT
U. S. A.

THE JAMES JACKSON CABOT PROFESSORSHIP
of
AIR TRAFFIC REGULATION
and
AIR TRANSPORTATION

PREFACE

In presenting this treatise on the evolution of combat airplanes, I do so with a deep sense of the honour which has been conferred on me, an English writer, by the James Jackson Cabot Foundation of Norwich University in asking me to write in this historical series. I believe that I am the first Englishman to have had that honour and I therefore appreciate the compliment the more.

To follow such distinguished writers as my friend Dr. Edward Warner, and that world-wide air traveller Parker van Zandt is a difficult task. But still more intimidating was the prospect of writing anything which could stand comparison with Colonel Gorrell's great historical discussion of the effort of the United States in the air during 1917-18, which is the preceding work in this series. His facts and figures are of high value, besides being, although more than 20 years old, startling news to those in the American and British Air Forces and aircraft industries who have the intelligence to study them. The object of this treatise is to give in not too technical language, for the benefit of those who are interested but are not specialists in aeronautical affairs, a concise history of how combat airplanes have evolved themselves, or have been developed, from the early and somewhat crude airplanes of before the War 1914-18. It is in four parts.

Part I deals with the evolution of fighting airplanes between the outbreak of war in August, 1914 and the Armistice in November, 1918. Part II deals with the same process between wars. During this twenty years almost every country has tried to build airplanes, but most of the development was done first in England (because the R.A.F. has been continually at war since August 4, 1914, in one part of the Empire or another), then in France and Italy, contemporaneously, then in Germany, when the Versailles Treaty was scrapped, and then with a sud-

den rush during the past three or four years, in the United States. But throughout those twenty years two or three pioneer firms in the United States have pursued their own lines of development in combat airplanes, and to those firms, as will appear to readers, the world owes many of the most important steps in progress and development.

Part III deals with what has been produced during this war, and somewhat with the operations of 1939-40-41. Part IV deals with armament, armour and, to some extent, with the tactics of modern combat airplanes.

CHARLES G. GREY

INTRODUCTION

Before discussing combat airplanes the reader and the writer had better come to an agreement about what in fact is a combat airplane. One might argue that any airplane which is used in war may be called upon to fight for its life, and that therefore any warplane is a combat airplane. But that would include such things as troop carriers which do not carry any armament except perhaps a few machine guns in the hope of beating off an attack by enemy fighters. It would also include high-speed photographic scouts which carry no armament at all, but are none the less warplanes. Therefore we had better agree that a combat airplane is a warplane which is primarily designed as a fighting machine.

In this category we shall certainly have to include even the heavy bombers. Although their first reason for existing is to deliver bombs on the enemy which is in itself a form of combat in that they have to get through enemy anti-aircraft fire to deliver their own explosives—the bombers are heavily armed in these days, to such an extent that one bomber can, and often does, beat off half a dozen attacking fighters.

There are also certain airplanes which, without alteration in their structures, can be used either as bombers or fighters according to whether they are fitted with a few guns and a lot of bomb racks, or a lot of guns and no bomb racks. We can consider those in detail later on.

Then there are the combat airplanes proper, the high-speed pursuit ships designed to catch enemy aircraft by a stern chase and shoot them down. Also, but in a different category, there is the interceptor, almost always a single-seat fighter, but designed primarily to have a very high rate of climb so that it may, after the shortest possible warning, fly above the height of the high-flying bombers and shoot them down from above.

Furthermore, besides the pursuit ships and interceptors, there are two-seat fighters which carry heavy armament. All three types are used for night fighting. And there is also a tendency to use twin-motor light bombers as night fighters.

Yet another type of combat airplane is the ground attack machine, which came into use towards the end of the War of 1914-18, and was commonly known as the ground strafer. It was designed particularly to attack enemy troops on the roads or in action. Both the English and the Germans developed the type in the last war but for some inexplicable reason it has been completely neglected in the years between the wars, although some writers on air affairs have strongly advocated progressive experiments in ground strafing.

Closely allied to the ground strafer, which is itself a development of the single-seat fighter, is the dive bomber, which is designed to bomb targets on the ground at short range. This is, strictly speaking, a combat airplane in that it carries guns forward and aft although its chief function is to bomb people on the roads and to demolish anything which blocks the progress of the high-speed mechanized troops of a modern army.

Before turning to the history of development there is interest in noting that, perhaps naturally, the armies and navies of the Great Powers had much to do with the earliest history of airplanes. There is a tendency among aviation people to think that, when flying first began, fossilized Generals and bone-headed Admirals refused to recognize the potential value in war of airplanes. So far from that being true, serving officers of high rank were among the first to advocate the development of aircraft, and serving officers of junior rank were, in all nations, among the earliest aviators.

I am certainly right in stating that the first Army officer in the world to fly was Lieutenant Selfridge of the U. S. Army. He was one of that gallant little band of pioneers known as the Aerial Experiment Association, which was composed of Dr. Graham Bell (Edison-Bell Telephone and Phonographs) of Baddeck, Nova Scotia; Glenn Curtiss, whose home was beside Lake Keuka, by Hammondsport in the State of New York, already world famous as a motorcycle racer and designer; J. A. D. McCurdy, of Montreal, now a considerable financier; F. S. "Casey" Baldwin, also a Nova Scotian; and young Mr. Selfridge. They built and flew biplanes in 1908. The Wright Brothers had made the first man-lifting flight in

1903 and their second in 1906. The Wright Brothers began by launching their machine by catapult, a method which now is called "assisted take-off", and only now is being taken seriously, although airplanes were catapulted from ships in 1918.

An interesting fact to anybody who is doing any research into American aviation of that period is that one finds, among the experimenters of 1908-9, Charles Lawrance, whose Aero Engine Corporation eventually was taken over by Curtiss-Wright and whose aero-motor thus was the precursor of the present Wright motor; and Grover Loening, still adviser on aeronautical subjects to the U. S. Government.

In England we already had an Army Balloon Factory which later became the Royal Aircraft Factory, and is now the Royal Aircraft Establishment. The old balloon factory had to its credit, under Colonel Templer and later under Colonel Capper, the encouragement and financing of that notable American citizen, Mr. Stanley Franklin Cody, who, still an American citizen, built the famous Cody biplane, which was the first airplane built in England to fly off British soil. But again the Army was among the pioneers, for Lieutenant J. W. Dunne of the Middlesex Regiment had been experimenting secretly with gliders on the estate of the Duke of Athol in Scotland, and by 1909 had produced an automatically or inherently stable biplane which flew. Captain Bertram Dickson of the Royal Artillery was the owner and pilot of a Farman biplane, and Captain J. D. B. Fulton, also of the Royal Artillery, was the owner of a Bleriot monoplane in 1908.

Their Lordships of the Admiralty had already arranged for the building of a big airship, the construction of which was in charge of Captain Murray Sueter, a pioneer also of submarines and now Rear-Admiral Sir Murray Sueter, M. P. He, in the years which followed, built up the Royal Naval Air Service. Also a Naval Officer, Lieutenant John Porte, was experimenting with gliders in 1909. Soon after he became one of the most notable pilots in England. In 1914 he went to America and worked with Glenn Curtiss in building an experimental flying boat. This connection between Curtiss and Porte pro-

vided England during 1914 with a number of training machines and many of our best flying boats.

Another British pioneer of that period was Mr. J. T. C. Moore-Brabazon, a member of an old Anglo-Irish family, to which the Earls of Meath belong. He had already acquired a Voisin biplane and made the first flight in England over a closed circuit exceeding a mile in circumference. Later he won the Military Cross in the Royal Flying Corps and became a pioneer in military aviation. At the time of writing he is Minister of Aircraft Production, and handles those excellent airplanes which are now reaching us from the United States.

Admiral Sir Percy Scott, R. N., the great gunnery expert of the British Navy, had by the beginning of 1909 delivered a discourse on Aerial Warfare.

In France one of the earliest pioneers was Captain Ferber, who built, and flew to a limited extent, a biplane of his own during 1908. And the French Army, which had long had an Airship Corps, had begun to build an experimental airplane which never developed into anything. Most of the development of French airplanes was done by military sportsmen or by enterprising business men.

In Germany Major von Parseval, already noted as an airship designer, had built a monoplane, and Lieutenant Fritsche had acquired a French airplane. The German Government at that time was more interested in Zeppelins and Parsevals than in any other aircraft but it soon turned its attention to airplanes when they became practical.

In Italy, the three great pioneers of aviation were Naval Lieutenants Guidoni, Savoia and Calderara. The last named bought a Wright biplane on behalf of the Italian Government. Some twenty years later he became the Italian Air Attaché in Washington, and in 1939-40 his brother, General Calderara, was Italian Air Attaché in England.

I hope that these brief notes will dispose of a popular idea that the fighting services of the nations were or have been dilatory or stupid or obstinate in dealing with the use or progress of the Air Arm.

Certainly, writing as a critic of British aviation, I can say definitely that there was a period round about 1920 to 1929 when British aviation would have died but for the steady policy of support for the British aircraft industry which was laid down by Air Marshal Sir Hugh Trenchard, then Chief of the Air Staff, and by Sir Samuel Hoare, then Secretary of State for Air.

They set forth a scheme for the progressive development of the Royal Air Force, which, if it had been kept going without political interference and our disastrous policy of disarmament, would have given us by 1937 or 1938 a bigger air force than any European power had. And in spite of lack of money, those two great men laid the foundations on which the present tremendous expansion of the Royal Air Force was possible.

When he was leaving the Air Ministry in 1930 Lord Trenchard said that he had laid a foundation on which a castle could be built, and that, if nobody ever wanted to build anything bigger than a cottage on it, at any rate, it would be a very good cottage. Today we have built on that same foundation not merely a castle but a vast fortress, from which sally-ports already lead into the enemy's country. And fortunately there is still a very good postern-gate or back door, through which the United States can supply us with airplanes fabricated according to the best American machine-shop practice, and designed since the middle of 1940 to embody all the accumulated experience of intensive air war by day and night.

Writing as one who has been very closely in touch with the leading men in the American aircraft industry ever since I met Glenn Curtiss at Reims in 1909, I can say without fear of contradiction that American airplanes have always had fine qualities as flying machines. In the years between the wars our aircraft industry learned much from the United States about detail design and construction of airplanes. And, since the war broke out, American aircraft designers have reciprocated by willingly learning from our British experience an equally great deal about the proper armament of combat airplanes. The combination of British and American brains and energy is definitely undefeatable.

Part I

THE WAR OF 1914-18

Before the outbreak of war in August 1914, there was no such thing as a combat airplane. But some attempt had been made in the direction of arming ordinary airplanes. In the United States sundry gallant people had mounted machine guns in the noses of pusher biplanes and fired them. I have no documentary evidence but if my memory is good somebody fired a Lewis gun between his feet while riding as a passenger in a Wright biplane. And I believe that both Glenn Martin and Glenn Curtiss experimented with guns from airplanes.

Certainly at the outbreak of war in 1914 the U. S. Army and Navy had no aircraft which could be classed as fighters. But as an aside perhaps I may remark here that in the course of this research I discovered a list of U. S. Army and Navy aviators. The first name on the list is that of "Arnold, Lieut. H. H. (29)" now General Arnold, Commanding-in-Chief the U. S. Army Air Corps. And the fourth name on the Navy list is "Towers, Lieut. J. H. (22)" now Rear Admiral John H. Towers, Chief of the U. S. Naval Air Service—so sometimes pioneers reap a reward.

In England we had in fact made some slight steps in the direction of producing combat airplanes. Vickers Ltd., whose air branch had been established by Major Herbert Wood (12th Lancers) since deceased, and by Captain Peter Dyke-Acland (Indian Cavalry) in the Brooklands Motor Racing Track, by that time quite notable as an aerodrome, had built a pusher biplane with a monosoupape rotary Gnome motor of 100 h. p.

This product of the Vickers works was not unlike a Farman biplane in general layout. It carried a Vickers gun in the nose, which was mounted on a swivel and operated by the observer who sat in front of the pilot. The machine was familiarly known as the "Vickers Gun-bus". But although it was built and flown before the declaration of war no squadron of the Royal Flying Corps was armed with it. Nevertheless it was the first British airplane designed definitely for combat.

Furthermore, before the Gun-bus was built, Short Bros. Ltd., now famous all over the world as builders of the Empire Flying Boats, and more recently of the Sunderland Patrol Boats, had built a large pusher biplane mounted on floats which had a Salmson Canton-Unné engine of 200 h. p. In the bow was mounted a two-pounder quick-firer of a type which was then standard in the Royal Navy. A young naval officer named Robert Clark-Hall, piloted by one or other of several brother officers, used to sit up in the bow of this contraption, which was like a pulpit, and poop off this two-pounder gun. The legend at the time was that whenever he fired it the airplane stood still because of the recoil. Whether he ever hit a target with it is not recorded. But his courage in daring to fire the thing in a structure made of timber and steel wire, or stick-and-string, as we used to call that method of construction, is noteworthy. There is interest also in noting that both these airplanes had a top speed of approximately 70 m. p. h. The young officer is now Air-Marshal Sir Robert Clark-Hall, K.B.E., C.M.G., D.S.O., R.A.F., rtd. Thus is virtue sometimes rewarded.

Perhaps I should note here that in 1910 Sir George White, the pioneer of electric tramways in the Empire, with his usual foresight, had founded a firm called the British and Colonial Airplane Co., Ltd. Also in 1910 a young man called T. O. M. Sopwith had come into aviation as an amateur and in 1911 had started to build airplanes seriously.

In 1912 Frank Barnwell, chief designer for the Bristol Company, produced a small biplane single-seater with an 80 h. p. Gnome motor, which had the phenomenal speed of 95 m. p. h. Almost simultaneously the Sopwith Aviation Co., produced a very little single-seater which was nicknamed the "Tabloid". That machine with a 50 h. p. Gnome had a speed of about 84 m. p. h. and a landing speed of less than 30 m. p. h.

Although these two little machines were not armed they were in fact the direct ancestors of all the biplane fighters of subsequent years. And, remember, the biplane fighter has survived until the present day. There are biplane fighters in the U. S. Naval Service, and the R. A. F.'s Gloster Gladiators have done excellent work in Norway and also in Libya and in Greece, be-

cause they have been able to land in and get out of ground which would wreck a high-speed monoplane fighter.

In France, apart from the mounting of machine guns experimentally in the noses of Farman and Voisin pusher biplanes, there was no attempt to produce fighter airplanes. But the firms which afterwards became famous as manufacturers of fighters, such as Morane-Saulnier and Nieuport, were already established, together with a lot of others which died out as soon as war started.

In Germany, so far as I can trace, there is no evidence of airplanes being specially designed for fighting. The German idea of military airplanes was machines for the dropping of bombs and scouting. There also the firms which became famous as makers of combat airplanes were already established. Anthony Fokker's monoplane of 1914 was quite definitely the ancestor of all the succeeding Fokkers. Although it was primarily a copy of the French Morane, its side elevation was definitely Fokker. The names of Gotha, L. V. G., and Rumpler were already known.

Likewise in Italy, although no fighting craft had been built, Gianni Caproni was already established in business.

THE FIRST YEAR OF WAR

The year 1915, the first year of real air war, naturally produced the first real development of combat airplanes. When the Royal Flying Corps (R.F.C.) went to war they had but the haziest idea of what air fighting meant. The single-seater Bristol Scout biplanes, faster than anything else in the air, were obviously the right things with which to shoot down the slower German reconnaissance machines, which were a mass of wire and struts and undercarriage tackle. But nobody had then discovered a way of arming them.

The fact is on record that the first German airplane to be forced down was intimidated rather than shot down by Lieutenant F. Vesey Holt, flying a Bristol Scout. The story is that he flew over the top of the German's machine on a steeply-banked turn and shot at him with a revolver which he rested on the edge of the cockpit.

The bulk of our reconnaissance was in fact done by the famous, or perhaps I should say notorious, BE-2c biplane, designed by Mr. Geoffrey de Havilland, and built at the Royal Aircraft Factory for the Military Aeroplane Competition of 1912. As a government product it was not allowed to compete, but it went through all the tests better than anything else except the colossal biplane of the winner, S. F. Cody.

In the BE the pilot sat behind and the observer in front where he could see over the leading edge of the lower plane. As the upper plane was over his head, and he had struts and wires all round him, and the motor and air-screw in front, the observer had little field of fire. Some of them carried ordinary service rifles in the hope of being able to get a shot outside of the circle swept by the air-screw, by poking the gun between the wires and the struts. Sometimes they fired downwards over the leading edge, and sometimes they fired backwards past the pilot's head, but that was later on when Anthony Fokker produced the first tractor-screw fighter.

Late in 1914 Captain Geoffrey de Havilland, (Captain in the Reserve of Officers of the Royal Flying Corps) had left the Royal Aircraft Factory, Farnborough, and had joined a new firm called the Aircraft Manufacturing Co., Ltd., which was founded by Mr. George Holt-Thomas, and there began the world famous series of DH airplanes which now I believe run somewhere up towards a hundred different types.

The first of these was a two-seater pusher, much like the Vickers Gun-bus. It never attained much production or fame. But the DH-2 was one of the classic fighter planes of the war. It was a small pusher single-seater and had a monosoupape (single valve) Gnome of 100 h. p. It had a single Lewis gun mounted just in front of the pilot on a pivot, so that it could be fired sideways, or it could be locked and used as a fixed gun which was aimed by manoeuvring the airplane as are the front guns of practically all combat planes today.

The beauty of the machine as a fighter was that the gunner had a clear field of view over a full hemisphere in front and a considerable view over and behind the upper plane and downwards past the lower plane. The swivel gun had advantages

because, although one could not aim it when it was turned away from the direct front position, the pilot could demonstrate with it against an enemy.

An Australian friend of mine flying a DH-2 was attacked by the great German pilot, Boelcke, and although the little DH-2's speed was no match for Boelcke's Fokker, it could turn inside it on a smaller circle. At one moment my friend found himself on the opposite side of the circle to Boelcke. He trained his gun across the fuselage and fired along the chord of an arc of the circle at the German pilot. Naturally he could not aim the gun because the barrel was by then right athwartships, but by judgment, like a man shooting an automatic from his hip, he managed to get some bullets across and so scared the German pilot that he broke off the fight and flew away.

The Royal Aircraft Factory somewhat later produced the FE-8 which strongly resembled the DH-2. The difference was that in the DH-2 the tail booms converged on a horizontal plane to a vertical stern-post on which the fin and rudder were fixed, whereas in the FE-8 the tail booms converged up and down to a horizontal tube to which the tail plane and elevator were fixed, the rudder and fin were carried on a vertical post at right angles to the horizontal bar.

MACHINE GUNS SYNCHRONIZED

In France during 1915 the first step towards producing a genuine fighter with a tractor-screw was taken by that gallant little sportsman, Roland Garros. He fitted a machine gun in front of the pilot so that the bullets would fire straight through the air-screw. And to prevent them from hitting and clipping the blades, he fitted to each blade a deflector plate at such a radius from the centre as to bring the deflector opposite to the muzzle of the gun.

Thus, when the gun was fired, if any particular bullet had an inclination to hit the blade, it was caught by the deflector plate and thrown off. The device worked well enough, but one disadvantage was that the plate on the air-screw blade used up an astonishing amount of power. Another drawback was that the

impact of the bullet on the deflector plate was liable to break the air-screw, and the bullets even ricocheted back into the airplane as they were fired. It was crude but it worked.

Garros shot down a number of unsuspecting German pilots before engine failure let him down in the German lines where he was taken prisoner. Later he escaped and rejoined the French Air Arm only to be shot down and killed a few days later.

The next development was the invention of the synchronized machine gun by Anthony Fokker. He was building Morane-like fighter planes for the German Army. When Garros was captured Fokker was invited to Berlin to see how the deflector plate was fitted to the Morane air-screw. Within forty-eight hours Fokker, seeing the drawbacks of the deflector plate, had invented a gear which fired the gun only when there was no air-screw blade in front of the muzzle.

In his fascinating book "Flying Dutchman", his autobiography, Fokker says,—"the technical problem was to shoot between the propeller blades, which passed a given point 2,400 times a minute. Inasmuch as the machine gun would shoot about 600 times a minute, this required some practical working out, but the principle had been found, which was the important thing."

He then discusses the technical points of the synchronizing gear, which are intensely interesting but would take up too much space in this discussion. His descriptions of the various tests to which his machine and his invention were put by the German High Command are most amusing. And his description of how he avoided actually demonstrating the device in action against the French are equally diverting. Also they are an essential part of the history of the combat airplane. The book was published in New York by Henry Holt & Co., in 1931.

Much about the same time—evidence is lacking about which came first—a Rumanian named Constantinesco invented a synchronizing gear which worked by impulses transmitted through liquid in a pipe between a cam on the air-screw shaft and the firing mechanism of the gun. Also a young Australian engineer named Kauper, who was employed by the Sopwith Avia-

tion Co., invented an interruptor gear which worked in the opposite direction by stopping the gun firing as a blade of the air-screw passed the muzzle and left it free to fire in between.[1]

REAL AIR FIGHTING

The result of these inventions was an outbreak of air fighting on a really big scale. All the German Fokker planes, and a very good make of biplane called the Albatros—not spelt with a double s in German—and Rolands were fitted with the Fokker synchronizer or something like it. On the other side Bristol and Sopwith Scouts, the French Moranes and Nieuports were fitted with either synchronizing gear or interruptors.

Then the pusher fighters became obsolete although actually the DH-2 and the FE-8 went on fighting at an unfair disadvantage for at least another eighteen months.

One particularly interesting historical fact emerges at this stage. The American Sturtevant Co., who had been famous for years as the makers of ventilator fans, known as Sturtevant Blowers, went into the aircraft industry, with the idea of selling machines to the British and French. They produced a big biplane with a single motor, and alongside the interplane struts, outside the area swept by the air-screw, they built a little cockpit, carefully streamlined, in which sat a man with a machine gun. That, so far as I can trace, was the first step in the United States towards designing an airplane *ad hoc* for air combat.

Interesting facts about the U. S. "Sturtevant Battle Airplane" are that it was designed by Grover C. Loening, and that it was the first airplane in which guns fixed on the wings fired outside the air-screw disc. This is now the practice in all modern high-speed fighters with a single motor, the difference

[1] An old friend of mine, Percy Maxwell Muller, one of the pioneers of Vickers Aviation has suddenly bobbed up in the *Aeroplane* newspaper with the statement that the *first* gear designed to synchronize guns firing through the airscrew was produced by a designer named Challenger, who designed the original Vickers Gun-Bus. He produced the gear in 1915 and it was built in quantities by Vickers at Weybridge. The gear was driven from the end of the crankshaft through a reduction box and the rate of fire was determined by the revolution of the engine. The Vickers Company's Challenger gear was used on the early Sopwith 1½-Strutters before the Kauper gear was perfected.

being that instead of having a man to fire one gun on each side of the air-screw, there are four guns on each side all fired automatically.

The Sturtevant biplane had an eight-cylinder Vee-type motor of 140 h. p. which was made by the Sturtevant Co. Many of these motors were sent over here, but they refused to run for more than a few minutes, and some time later the discovery was made that sabotage had taken place during the process of manufacture and that the water-ways round the cylinders had been blocked up.

Another interesting fact about 1915 in the United States is that Thomas Bros. of Ithaca, New York, who had begun their experimental flying in 1908, produced a tractor biplane with a 160 h. p. Curtiss Motor which was the first American airplane to exceed 100 m. p. h. The Thomas brothers, if I recollect rightly, were wealthy young men who drew their wealth from estates in the Argentine Republic.

The immediate result of fitting synchronizer gears by the Germans was the wholesale shooting down of our BE-2c reconnaissance planes. This point is worth noting because I will show later on how history repeated itself in this war twenty-five years later. The speed of the BE-2c was about 75 m. p. h. It was a delightful touring machine, beautifully made, but it was hopeless as a war machine. The German fighters came along with their synchronized guns, doing a matter of 100 to 120 m. p. h. and massacred the unfortunate BE-'s, which were slogging up and down the line on artillery observation.

We at that time had no fighters to meet them. The result was that the BE-2's became known as "Fokker Fodder". And the prospect of being shot down in spite of the gallant efforts of the observers, with rifles to shoot through the struts and wires over the tail at the attacking Germans, seriously affected the morale of the Royal Flying Corps. The worst of it was that there was no alternative machine available, because the Air Department of the War Office, under pressure from the Royal Aircraft Factory had standardized on the BE type and had refused to buy airplanes built by independent firms.

Then right at the end of 1915, came the next big step in the development of combat airplanes. The Sopwith Company had, in 1911 and 1912, received encouragement from the Air Department at the Admiralty, controlled by Captain (now Admiral) Murray Sueter, and the brilliant band of Naval engineers and Naval officers who formed the Royal Naval Air Service. Their policy had always been to encourage private enterprise and to buy as many varied types as they could, provided they came up to the strength and performance required, so the members of the Royal Naval Air Service gained experience of several different types and discovered what went towards making the best possible warplane.

Consequently it kept alive a number of young and promising firms, which, when war broke out, were able to expand quickly and were able to boost the supply of airplanes for the Navy, which was in effect carrying on a private war of its own with a base at Dunkirk, quite independently of the Royal Flying Corps and the British Army, and of the British Navy itself which as a whole had no use for aircraft. A few far-seeing Naval officers of that day, unpopular with their fellows, recognized the importance of fighting and bombing and torpedo aircraft. They now are all either dead or senior officers in the Navy, which accounts for the growth and efficiency of our Fleet Air Arm today.

THE AFT-GUN FIGHTER

As the war in France settled down to regular air action, the Naval Air Service, who were watching things very carefully, and the Sopwith Company, which kept in touch with everything going on, spotted the damage which was being done by the German fighters with the synchronized guns. So they devised a Sopwith two-seater in which the pilot sat in front under the upper plane and had a synchronized gun in front of him, while his observer sat behind him in the middle of a ring of steel tubes, on which was mounted a machine gun. This arrangement was the invention of Mr. Scarff, a Warrant Officer R. N., one of the early people in the R.N.A.S. Inside this ring the pilot could turn around sitting on a kind of piano stool, and

could manoeuvre his gun in any direction up or down or sideways.

Consequently, barring the area blanked off by the fin and rudder and the elevators, and such portions of the body, or fuselage, as might get in the way of the gun, the aft gunner had a clear field of view of considerably more than half a sphere. Thus, when a German fighter spotted the innocent-looking biplane and came cavorting across the sky to swoop down on its tail, he was apt to find himself blasted out of the sky by the aft gunner.

Later on Mr. Scarff mounted a twin Lewis gun on this ring and one of the most dangerous things the German fighter could do was to attack this Sopwith.

Here I may note that because of the curious arrangement of struts in the centre section of the plane, which made it look as if it only had one-and-a-half struts on each side, it became known as "1½ Strutter."

It went far to save the morale of the R.F.C. in July of 1916, because the R.N.A.S. had, with admirable foresight, told the Sopwith Co. to go ahead and make all the machines they could. So in those days the Navy was not only able to lend two complete squadrons of men and machines to the R. F. C. during the Battle of the Somme, but it supplied enough 1½ Strutters to the Army to equip several R.F.C. squadrons.

An interesting point hereabout is that because of what came to be known as the "Fokker Scourge" in 1915, an Air Inquiry Committee was set up by the Government to inquire into the maladministration of the Flying Services. In fact there was not much the matter with the Royal Naval Air Service except that it was never properly used by the Navy, and Commodore Sueter, as he had then become, was practically left to conduct a private air war on his own account. Members of Parliament laid the charge that pilots and observers of the Royal Flying Corps were "murdered rather than killed" through official negligence. Among the evidence was the fact that the Sopwith 1½ Strutter already existed before the end of 1915, and that samples of it were ordered by the French Air Service before any were ordered by the R.F.C.

The French aircraft industry in 1915 had nothing novel in the way of fighting machines. Their standard Nieuports and Moranes were fitted with interruptor gears or synchronizer gears, and became very useful combat airplanes, or pursuit ships, whichever one likes to call them.

The Nieuport people introduced one idea which led to developments. They built a two-seater in which the passenger sat in front of the pilot, and they cut a hole in the upper plane, and mounted a machine gun on top. When an enemy aircraft was sighted the passenger was supposed to stand up, project his head and shoulders through the hole in the upper plane, and then fire the machine gun over the top of the air-screw. As the speed of the machine was only 72 m. p. h. (optimistically) the passenger's job was cold but not impossible. And naturally when he stood up the added resistance of his body probably reduced the speed somewhere nearer to 50 m. p. h. at which speed the function of the machine as a pursuit-ship ceased, even in those days.

But from this idea another was developed, which had quite an effect on air combat. When the Royal Flying Corps took over a number of Nieuports and fitted them with interruptor gear and a gun which fired straight ahead through the air-screw, they also fitted a gun mounted on a hinge and a pivot on the aft spar of the upper plane, so that when the pilot climbed up below or dived underneath an enemy machine he could fire up into the belly of it, where the enemy gunner could not fire back at him. This gun sticking out in the open air definitely slowed the machine by a good many miles an hour, but our fighting pilots felt that it was worth the cost.

In 1915 we began to hear something about the German Albatros fighters. By the end of the year the pigeon-wing type of monoplane, known as the Taube, or Dove, had practically disappeared and they began to use monoplanes and biplanes of more or less normal types. Some of them, indeed, would be considered quite good designs to-day.

Another German make which began to make a reputation was the Halberstadt, a firm which had been before the war linked up with the British Bristol Co. and their new machines had a

remote resemblance to the Bristol. This was one of the first German machines to carry a gunner behind in the manner of the Sopwith 1½ Strutter.

In Italy during 1915 we first began to hear of the Macchi monoplane, which was a modification of the French Nieuport. Later this became one of the best and fastest of Italian airplanes.

The Germans, until the outbreak of war, had kept steadily to water cooled motors, modified from their well tried automobile engines, but in 1915 they took to making rotary air cooled engines for their lighter scouts which became fighters. The leading engine of that type was the Oberursel. A few of these engines were built before the war under licence to the Gnôme Co. to which the firm were doubtless inclined because they themselves for some years built a stationary agricultural motor called the Gnôme. After the outbreak of war the Oberursel Co. went on making Gnômes but apparently modified their designs from time to time as later types of Allied motors were captured.

CHANGES IN 1916

Largely as the result of the political agitation already mentioned, 1916 became a real year of progress. The War Office changed its policy and took to encouraging private enterprise instead of trying to standardize on officially designed types of airplanes and motors. Nevertheless the civilian officials behind the scenes used all the influence they could to thrust the official designs upon the Royal Flying Corps. The Navy would have nothing to do with them.

During 1916 the Royal Aircraft Factory turned out a series of pusher biplanes which might fairly be classed as combat machines. These were known as the FE, more commonly called "Feeplanes" by the R. F. C.

They were big clumsy biplanes in which the observer sat in front of the pilot with a machine gun on a swivel. The first to go into service was the FE-2b the second modification of the second type. It had a Beardmore water cooled six cylinder motor of 120 h. p. and its speed was probably about 70 m. p. h.

This was followed by the FE-2d. Nobody seems to have heard of the FE-2c. The 2d was notable because it had one of the early Rolls Royce Eagle motors of 250 h. p. Naturally it was faster than the 2b, but the bigger engine and the bigger radiator made it a bigger airplane altogether, so it was not so much better as the added horsepower would indicate.

For historical purposes perhaps I may here give the information that the Royal Aircraft Factory types were known as the BE, FE, RE, and SE. The BE officially meant British Experimental, but it was in fact originally so called because M. Bleriot was credited with having originated the tractor type of airplane, and the machine was called the Bleriot Experimental.

Similarly FE originally meant Farman Experimental, as the Farman Bros. were given credit for the pusher type. But the Royal Aircraft Factory modified this to mean Fighter Experimental, on the strength of the machine having a gun poking out of the nose. As I have already mentioned, the FE-8 single seater, which was an imitation of the DH-2 was intended as a fighter.

RE indicated Reconnaissance Experimental. That was a big tractor biplane which began its service as a death trap and ultimately became quite a decent airplane, but not being a fighter it does not interest us.

The last of the Aircraft Factory type, the SE, which meant Scouting Experimental, turned out to be their one valuable contribution towards winning the war. This machine was designed by Mr. H. P. Folland who later left the Factory and designed that series of Gloster high-speed biplanes which competed in Schneider Trophy contests, put up a number of British air-speed records, and eventually produced the Gloster Gauntlet and Gladiator. The latter turned out to be the fastest biplane single-seat fighter which the world has seen or is likely to see, now that biplanes have fallen into disuse.

Another successful British fighting machine of 1916 was the Martinsyde Scout, which had a Beardmore motor of 120 h. p. at first, and then a 160 h. p. Beardmore. The Martinsyde title was made up of the names of Martin and Handasyde, who

were among the 1908-9 pioneers of British aviation. In lay-out and performance the Martinsyde was in the front rank of combat airplanes, and the bankruptcy of the firm after the war robbed the world of a valuable aid to progress.

A notable fighting machine which came into use during 1916 was the Sopwith Triplane. It was a queer looking little kite, and that is the right word for it. The lower plane was underneath the fuselage, the middle plane was planked on the top of it so that the pilot could look over it, and the third plane was about the same distance above the middle one as that was above the lower plane. It was not very fast but it had a terrific climb and because of its short span was extremely manoeuvrable.

It got its results by climbing after the enemy and then diving down on him. One of its chief defects was that if the pilot pulled out of the dive too quickly he was liable to pull his top plane off. That generally meant a fatal crash, because in those days nobody had parachutes.

During 1916 also the Sopwith Co. produced a somewhat enlarged and improved version of the old Tabloid, which became known as the Sopwith Pup. It was faster than the Triplane and likewise had a very high climb. There is interest in recording that in 1915 the Sopwith two-seater tractor biplane which became known as the 1½ Strutter, set up a British height record of 18,400 ft. This was beaten by a Naval pilot flying a Sopwith Pup which passed the 25,000 level.

FRENCH PROGRESS

During 1915-16 the French Morane was greatly improved and with an 80 h. p. Gnôme or Le Rhône motor as single-seaters approached a speed of 80 m. p. h. The Morane "Parasol" monoplane became very popular because it was very manoeuvrable and, as the one plane was high up, the pilot had an excellent view in front and below him compared with anything possible in a biplane.

In 1916 a new French fighter appeared which right up to the end of the war was the best of the French combat airplanes. This was called the Spad.

This is worth recording because it shows the quaint tricks which Fate plays in the history of nations. In 1911-12 a French dealer in silk named Armand Deperdussin took to making fast airplanes as a hobby. He was reputed to be a millionaire. One of his monoplanes designed by M. Béchérau and a young Dutchman named Koolhoven, who later became famous in this country and in Holland, set up a world's record by covering 124.8 miles in an hour—the first machine to convey a human being at more than two miles per minute for an hour.

Deperdussin spent so much money on his airplanes, on such a scale as would keep him in touch with the French Army Air authorities, that he went bankrupt, and when his affairs were investigated he was sent to jail for fraudulent transactions in silk. When his machine won the Gordon Bennett Cup in 1913 by doing that 124.8 miles in the hour, the pilot and the rest of the racing team sent a telegram to M. Deperdussin in prison, addressed to *"Le bon patron"* congratulating him on their success.

Soon after the outbreak of war M. Bleriot, the first aviator to fly across the English Channel, who had now become a great manufacturer, took over the Deperdussin business to preserve the organization and the collected talent of the firm. It then became known as the *Société Pour les Appareils Deperdussin*—hence the initials S.P.A.D. Later on when sentiment had died somewhat, the initials were given out as the *"Société Pour Aviation et ses Dérives"*.

M. Béchérau's experience was embodied in the new machine. It was fitted with a Hispano-Suiza motor which gave at first 150 h.p. and in later types 200 h.p. This was an eight-cylinder Vee-type water cooled motor and with it the Spad became the great success of the war as a fighting machine.

Designers of all nations learned a great deal from the Spad, which was very solid, very manoeuvrable and very fast. And it carried twin synchronized machine guns. Later on it was fitted with the first air cannon, but that must have a further reference when we get to the right stage in the development of fighters.

German progress in 1916 was also important. They made one good effort to build a pusher fighter to match the British Feeplanes. This was the Ago, which, instead of the ordinary tail booms had two slim streamlined fuselages. The tail plane and elevators lay between them and each fuselage carried a fin and rudder. Few of them were built but they were familiar enough on the Western Front to be known as "Two-Tails". The machine was called the Ago from the initials of the Aerowerke Gustav Otto, a branch of the Otto Engineering Co.

In 1916 the Albatros fighter rose to international fame. And it held its postion as one of the world's leading combat planes up to the end of the war. The Albatros single-seater fighter had a Mercédés-Daimler water cooled six-cylinder in-line motor of some 200 h.p. Its speed was reckoned to be between 120 and 130 m.p.h. at its best height. It had a carefully rounded and streamlined fuselage covered with three-ply wood which accounted largely for its speed.

The first of the famous Fokker biplanes appeared on the Front in 1916. It strongly resembled the French Morane but it had an upper plane carried very close to the top of the fuselage so that the pilot could look under the upper wing to aim a single synchronized machine gun, and could look over the trailing edge to see whether anything was coming at him from above. It had a single-valve Oberursel motor, a frank copy of the Gnome.

Another German machine which afterwards became famous was the Halberstadt which also appeared in 1916. It was a two-seater biplane with a Mercédés-Daimler water cooled engine of 220 h.p. An interesting point about it is that the firm was originally formed to build British Bristol airplanes under licence in Germany. The first type were single-seaters with a single gun in front. Later the Halberstadt developed into a very formidable two-seater which carried two guns forward and two guns aft.

Yet another notable German fighter which appeared in 1916 was the Roland, built by the L.F.G. firm (Luft Fahrzeug Gesellschaft). This firm was the successor of the original German Wright Airplane Co. The first Roland fighter was a biplane, in which the upper plane was built right down on the fuselage and

the pilot sat in a hole between the front and aft spars with his head and shoulders sticking out over the upper plane. The body was an excellent streamlined shape, and instead of having a mass of struts and wires between the upper and lower planes it had a single strut, very deep fore-and-aft, on each side. It had a Mercédés-Daimler engine of about 160 h.p. and it could climb to 2,000 metres (about 6,500 ft.) in 22 minutes.

A novelty among German single-seaters was the Pfalz, which in a general way was very like the Fokker and the Morane, but it carried two machine guns firing through the air-screw instead of one.

A German two-seat fighter which flew well in 1916 was the 150 h.p. L.V.G. (Luft Verkehrs Gesellschaft). This firm was originally formed to build French Farman biplanes. Its chief engineer was a Swiss named Franz Schneider. The L.V.G. was actually designed more as a reconnaissance biplane than as a fighter, but it had a gun aft mounted on a rather elaborate swivel arrangement, which was nothing like so neat as the Scarff and the Sopwith.

Thus we see British, American, French, Swiss and Dutch designers all had a hand in the best German fighters of 1916.

One of the most famous of the two-seat fighter class was the Rumpler, a big biplane which carried guns fore and aft. In a Rumpler a German aviator named Linnekogel had before the war put up a height record of something over 20,000 feet. Another pilot named Basser did 18 hours non-stop and later carried a passenger from Berlin by Budapest and Sofia to Constantinople in a day, stopping only at the capitals. Also in a Rumpler, Rudolf Boehm did just over 24 hours non-stop in September, 1914.

Strictly these facts have nothing to do with combat airplanes, beyond the fact that the Rumpler did fight when attacked. I thought well to put them in here just to remind the aviators of today of the quite astonishing flights which had been made before the War 1914-18.

Russia, which had distinguished itself before the war by producing the first four-motor airplane, designed by Igor Sikorsky (still very much alive), produced practically nothing in 1916. A

contemporary publication notes, "Russian official reports of German airplanes flying 100 miles or so behind the Russian lines indicate sufficiently clearly the deficiency in the Russian 'destroyer' force, and the prominence given in Russian communiques to single actions of Russian aviators indicates that there can be but few well mounted aviators in the Russian service."

In the United States during 1916, Glenn Curtiss produced a number of interesting airplanes which marked distinct steps towards modern types. First of all he built a very neat little biplane with the old familiar Vee-type water cooled 80 h.p. OX motor. Then a little later he built a triplane with the 100 h.p. Curtiss OX engine which had a top speed of 115 m.p.h. and a minimum speed of 55 m.p.h. And it climbed very fast. It was most progressive, for the air-screw carried a spinner which streamlined into the cowling of the motor, of which only the valve-boxes stuck out. The undercarriage was well streamlined, and the whole of the fuselage blended nicely into the tail unit.

Curtiss also built a cleverly streamlined biplane called the "Wireless" Scout because it had no wires between the wings. It had a little stubby lower plane which was braced by a tube through the wheel axle, and from the top of that brace a combined tension and compression strut ran to the upper plane. With the new 100 h.p. Curtiss engine it had a speed of 120 m.p.h. It definitely was the beginning of the combat airplane. Although it was never fitted with guns, and never flew on active service, the machine had in it all the makings of a small high-speed fighter.

None of the other American makers of that period went seriously into the problem of designing or building combat airplanes.

DEVELOPMENT IN 1917

The year 1917 was by far the most prolific, not only of the War of 1914-18, but, I think in the history of aviation so far as new development of warplanes was concerned. Until then other years had produced one single outstanding fighter, but 1917 produced a whole batch of them.

Naturally the machines which appeared in 1917 had been designed and some of them test-flown in 1916. But 1917, as the year of their public appearance, may be taken as their first real year of existence.

The British aircraft industry was particularly busy. At the Royal Aircraft Factory Mr. H. P. Folland produced the SE-5a, that is the first variation of the fifth model of the SE which has already been mentioned earlier. It had an Hispano-Suiza motor of 150 h.p. which carried a square-faced car-type radiator in front. Valve-heads stuck out at the sides, and in a general way it was not particularly good in outline or detail. But the thing had a wonderful performance. And in particular it was extremely manoeuvrable.

It carried two guns firing through the air-screw and, although some of the German machines were faster it was, taking it all round, about the best fighting airplane among the single-seaters, with the exception of the Sopwith Camel and later the Snipe, which in spite of having rotary engines managed pretty nearly to equal its performance, and if anything was rather more manoeuvrable.

The Aircraft Manufacturing Co. Ltd., produced the DH-4 which with a Rolls-Royce Eagle motor of 370 h.p. had, at 10,000 feet, with full load, a top speed of 133 m.p.h. And that included two guns forward and twin guns aft. Strictly speaking this was not a fighting machine but it was definitely a combat airplane because it was designed to go out on reconnaissance and fight its way through. Which it did with remarkable success.

Probably the most famous airplane of the lot was the Bristol Fighter designed by Captain Frank Barnwell. It was not quite so fast as the DH-4 but it was a remarkable fighting airplane. The pilot and the passenger sat practically back-to-back well up in the front of the fuselage and consequently were closely in touch with one another and worked together as a team. Although the Bristol was a big airplane, for the 250 h.p. Rolls-Royce Falcon, it was extremely manoeuvrable. It could be looped and spun and rolled just like a single-seater. And it was exceptionally strong. The pilot could dive it and

pull it out of a dive with complete confidence that his wings would not come off.

Here I must record the strange fate which seemed to await all our new types of airplanes. We had already presented to the Germans the first FE-2d, which came down in their lines because of an error of the pilot. But on Good Friday, 1917 twelve of the new Bristol Fighters crossed the lines for the first time, and only two got back.

Six were manned by experienced pilots but with new machine gunners, and six had new pilots with experienced gunners to protect them. They fell in with a bunch of German fighters and either the experienced gunners could not save the new pilots or the experienced pilots could not extricate the inexperienced gunners. I believe that several of the crews landed safely and spent the rest of the war as prisoners.

On the Easter Monday a squadron of DH-4's started out to bomb a railway bridge rather far back. They figured out that they could just about do the job in a flat calm. They took their machines out on the aerodrome, ran the engines up good and hot, filled up the tanks and started out. Then the wind changed and none of them had enough petrol to fight his way back. One was seen descending from a considerable height, with the air-screw stopped, or a "dead stick" as the pilots still call it, and was seen to crash in No Man's Land between the lines. Another was seen to alight near a Belgian aerodrome. The rest were shot down and the crews either killed or made prisoners.

And yet those two machines, the Bristol fighters and the DH-4's, were two of the finest airplanes that anybody could wish to fly and were thoroughly well fitted for reconnaissance work and fighting if they had to do it.

In 1917 also, the Bristol Co. produced an excellent single-seat monoplane with which they hoped to beat the world as a fighter. It was Frank Barnwell's ideal, as near as he could get it then, of the biggest possible motor with the smallest possible airplane behind it. The wings were about level with the top of the fuselage so that the pilot had a very good view over them but could not see well down the side of the fuselage

when coming in to land. So the machine was condemned by a senior pilot who was not one of the best in the R.F.C. Consequently instead of being sent to France, where it might have done very good work, a dozen or so of these monoplanes were sent to Palestine where those pilots who flew them still hold that they were the best fighting machine of that time.

The British single-seat fighter which was built in the greatest quantity in 1917, was certainly the Sopwith Camel. I should hesitate to say that it was the most popular, but those who learned to fly it properly swore by it. The Camel was fitted variously with the 120 h.p. Le Rhône motor or the 120 h.p. Clergêt, both of which were large rotary motors. These set up a powerful gyroscopic force in the nose of what was a very light airplane. The result was that when the machine was deflected from its course, the axis of the gyroscope precessed and pulled the airplane about in curious ways.

For example when the pilot pulled the machine round to the right the gyroscopic force of the motor tended to throw the nose down. Consequently the pilot had to use full left rudder to keep the nose up. If he did not, the airplane turned round and got into a right hand spin from which only an experienced pilot could get it out. The result was that many inexperienced pilots were killed by it.

Those who have read that best of all books of the last war, "War Birds", by Elliott White Springs, a wealthy young American from the South who came over to England as a near-Canadian along with several friends, and flew in the R.F.C., will get a first class idea of the peculiarities of the Sopwith Camel. According to his story the deaths among the American pupils at the Fighting School at Ayr, who had been trained on Curtiss "Jennies" with eight-cylinder water cooled engines, and were therefore ignorant of the habits of gyroscopes, were so many that they reckoned on one funeral a day, and as they only had one American flag to put over the coffin, if two men were killed on one day they kept one corpse back till the next day so as to be able to use the flag again. And yet those same American pilots became used to the Camel and swore by it instead of at it.

In the end Springs and his immediate friends were appointed to a fighter squadron, in which they did very fine work before transferring to American squadrons when the American Expeditionary Force, including the U. S. Army Air Service, arrived in France.

In France during 1917 there was a general reorganization in the hope of making the French Air Service efficient. Comparatively early in the war, when one of the earlier crises had happened in French aviation, somebody asked Marshal Joffre, "What is this crisis in French aviation?" And the old Marshal replied, "So long as there is aviation there will always be a crisis."

Those words still hold good and when one studies the reasons it is almost always found that the enemy has produced a new fighting machine which is playing havoc with the bombers and reconnaissance machines of the other side, which then suffers until it becomes better equipped. Which is one reason why combat airplanes are so interesting.

Moreover, because they are small and therefore comparatively cheap, the designs of fighters can be changed much more quickly than can the designs of the big bombers. And as each belligerent in turn comes out with something new in fighters so there is another crisis. We shall see more of that when we come to the present war.

One of the few real beauties in French fighters in 1917 was the XXVII-type Nieuport. It had a really well streamlined fuselage, and instead of the usual two pairs of struts on each side of the fuselage it only had two struts on each side. These started one at the front spar and one at the aft spar of the upper wing and formed a Vee the point of which was fixed to the single spar of the lower plane, which had a very narrow chord. It was a much prettier machine than any earlier French machine but it had a radial motor which only gave about 130 h.p. against the 150 h.p. water cooled Hispano-Suiza of the Spad.

In 1917 M. Béchérau produced an experimental fighter which was quite the funniest airplane of the war, and he was usually a most sane designer. As far as the air-screw it was very much a

normal Spad fighter. But he put a running bearing on the air-screw shaft in front of the screw, and on that mounted a kind of pulpit or cradle, just like the nose of an ordinary pusher machine. The weight of this thing was supported by four struts which ran down in front of the air-screw on each side, to the undercarriage. In this nosepiece a gun was mounted, and the gunner sat with his back practically up against the running bearing and within easy touch of the air-screw. It was a most precarious position because if the machine had a crash the whole weight of the machine and engine was bound to land in the middle of the gunner's back.

The only virtue about it was that the observer had about a three-quarter sphere of view. It was not much used during the war, and I imagine that after the war it quietly disappeared. A somewhat similar freak, nicknamed "the Pulpit", had been built onto a BE of some sort at the Royal Aircraft Factory at Farnborough early in the War, but it was soon scrapped.

An interesting fact about combat airplanes at this period was that in 1917 the Voisin Brothers, the oldest airplane firm in the world, founded in 1905, produced a two-seater gun-carrier which had a 47 mm. gun. That is nearly a 2 inch bore. The biggest gun which has been fired regularly in the present war from an airplane, is, I believe, the American Armament Co.'s 37 mm. gun which is about an inch and a half.

This machine, built in 1917, but obviously designed in 1916, had a pusher engine driving a propeller in among the tail booms in the old-fashioned Farman way.

Also, the machine had a four-wheeled undercarriage, thus anticipating by something more than twenty years one of the air fashions of today. The two front wheels were much closer together than the back ones so that in effect the undercarriage was very much that of the modern tricycle undercarriage.

I knew at the time that Voisins were fitting this machine with guns but I never heard of any results being achieved. The whole Voisin outfit was so clumsy that, what with the steel tubing and the four-wheel undercarriage, it was commonly known as the "Flying Bedstead". In taking off, when the pilot raised

the tail to gather speed the front wheels used to hit the ground, and so it bounced from back to front, and seemed to "canter" across the aerodrome.

Among the German machines there was also a general improvement. A new type which appeared during 1917 was the Hannoveraner, a two-seat fighter which had a biplane tail, that is to say it had the normal tail plane and elevators and a small tail plane without elevators stuck on top of the rudder. The idea probably was to make the machine steady as a gun platform for the aft gunner, but the plane on top of the rudder, small as it was, must have blanketed the fire at an attacker coming in aft.

The Albatros remained the leading fighting machine of the Germans. And in spite of the known shortage of material, it was always beautifully made.

Here, as it has a bearing on present day problems, I may remark that in England at this period we were terribly short of timber for airplanes. The United States had supplied us with all the suitable spruce available within sight of rail or river. Canada had likewise been stripped. The shortage was largely caused by the fact that the Aeronautical Inspection Department of the Royal Flying Corps insisted on everything being built up to a standard quite unnecessary in time of war. I have seen perfect pieces of spruce which had been fabricated into complete wing spars scrapped because of a flaw in the wood at a place where it did not matter. No constructor was allowed to use built-up or spliced spars until, about the end of 1917, material became so short that we either had to use spliced spars or none at all. This kind of nonsense went on in spite of the fact that every constructor knew that a properly spliced spar is, if anything, rather stronger than an unspliced spar although it may weigh a little more because of the glue and the binding.

Similarly in building air-screws, only slabs of perfect mahogany which could go straight through from tip to tip of the screw were allowed. By early 1917 the Germans were using screws which were built up of short lengths of mahogany or similar timber. They held together quite as well as our end-to-end screws.

We, in England, have learned something from those lessons and there is much less waste of material, in these days all metal, than there was in the last war. But in spite of this there have been, during the first eighteen months of this war, many examples of avoidable waste either through insistence on the use of scarce material when common material would have served, or through over-insistence on adherence to strict specification.

Apart from that, for years before the war, the steel merchants of Sheffield had been protesting against the absurdly large number of different specifications of steel on which aircraft manufacturers and the scientists at the Air Ministry insisted. Lieutenant Colonel Outram, who did so much to build up the Aeronautical Inspection Department (commonly known as the A.I.D.) during the last war and has been head of that Department from the end of the last war until after the beginning of this war, when he was transferred to the Ministry of Aircraft Production, has done a great deal to reduce these absurdities. But the duty of his department was to inspect not to specify.

LESSON FROM AMERICA

That is one of the lessons which our pseudo-scientists refused to learn from America. Unless things have changed very much in the past few years, the number of different specifications of the same material which are used in the U.S. aircraft industry are very small. At least fifteen years ago I was told by one of the chiefs of the U.S. Army Air Service, as it then was, that they would not tolerate fancy breeds of steel. They insisted that constructors should use plain chrome-molybdenum, or other simple stuff that one could buy "in any old store". He added, "A squadron in the field cannot carry a heat-treating plant with it, and if a ship has to make a forced landing and the pilot has to have a temporary repair to an undercarriage or a tail skid made by the local blacksmith, then any sort of fancy steel is a danger."

For years I have tried to drive that lesson home to our designers in England but they were all so much under the thumb of the self-appointed scientific authorities in the Air Ministry

and at the Royal Aircraft establishment at Farnborough that we just went on wasting money and material on what the Germans called "trick" steels when we could have done just as well with ordinary high-tensile commercial stuff.

These remarks may seem to belong rather to a technical section of this discussion, but they do belong here in the history of the development of fighters.

Let us now return to our study of the development of German fighters. One new fighter which appeared in 1917 was the Friedrichshafener. It was built by a branch of the Zeppelin Aircraft Co. which also built the big Friedrichshafen bomber. Although not strictly speaking a combat airplane, the Friedrichschafener was interesting in that it was a twin-motor pusher biplane. It was one of the very few twin-pushers built during the war. A. V. Roe & Co. built one but it was never put into general service.

The particular interest lies in the fact that today the only twin-pusher which is being built is Mr. Lawrence Bell's Airacuda, a bomber-fighter, the possibilities of which impress me more than those of any other airplane of new type which has been built for at least ten years.

The Friedrichshafener bomber carried guns forward and aft and guns down below to protect it against climbing attacks. The total weight of the machine loaded was just on 7,000 lbs. It was driven by two Benz motors of 225 h.p. each, which meant a lot of work for 450 h.p. to do.

An interesting point is that the famous Gotha bomber, which was in the last war as famous, or as infamous, as the Heinkel and Dornier are today, also had twin pusher screws but it had two 260 h.p. Mercédés-Daimler motors.

Anthony Fokker in 1917 followed the Sopwith Company's lead and produced a triplane. Our people who fought it thought highly of its manoeuvrability. Unfortunately I have no record of its speed, but a German statement said that these machines could climb 15,000 feet in 17 minutes with full load. With an Oberursel motor of only about 110 h.p. this was a very good performance.

The L.F.G. Roland which appeared in 1916 was also much used in 1917. At a distance a formation of Rolands was not unlike a formation of Sopwith Pups. I knew one instance of a Pup pilot losing his formation, seeing a formation of Rolands at a distance and joining them under the impression that he was joining his own formation. When they began firing at him he judged that he was unpopular, so he shot back and brought down two of them, much to his surprise.

Italy's one original contribution to the Allied war effort in the air appeared in 1917. That was the S.V.A. It was an interesting example of a great engineering firm going suddenly into the aircraft business, very much as Vickers Ltd. had done five or six years earlier. The airplane was built by Gio Ansaldo & Co. of Genoa and Turin. The name was taken from the Spa motor, Verduzio the designer, and Ansaldo, the makers.

The bosses of the Ansaldo firm were the brothers Pio and Mario Perrone, who might be compared to the Krupp family in Germany, or the Vickerses, Armstrongs, or Beardmores in England. Some idea of their importance may be judged by the fact that they employed more than 60,000 workpeople, and that when they decided to come into the aircraft business they raised a complete aircraft factory from green fields within eight months. Although all that happened more than twenty years ago it does show that even in those days people had ideas of high-speed development and mass production.

In the United States, before America came into the war, great strides were being made both in the design and construction of combat airplanes and in the organization of the Army and Navy Air Services. Unfortunately this is not the place in which to give details of that organization but it makes very interesting reading.

One interesting and rather curious fact is that the Curtiss Co., which a year or so earlier had shown signs of producing one of the best combat planes of that day, dropped that line of development in 1917. The reason was that they were so busy turning out big patrol flying boats that they deliberately neglected the fighter side. And nobody else took it up seriously.

GROUND ATTACK

Writing at the end of 1917 Major W. E. de B. Whitaker, one of the most far sighted contemporary writers on service aviation, at that time an officer on the Staff of Major General Ashmore, then commanding the London Air Defense Area, wrote:

"There has, however, during the past year, been one phase of aerial operation which constitutes the first marked change in the conditions of war since the days when the alchemists, intent on the search for an elixir of perpetual life, discovered somewhat unwillingly the constitution and property of gunpowder, thus with ironic fatality helping in the destruction of that which they most wished to preserve. The new practice which now, it would appear, has become a settled part of war, is the tactical employment of low-flying aeroplanes against troops on the ground.

"Before the introduction of gunpowder into the wars of Europe .... battles were largely a matter of hand-to-hand combat between the belligerents.... All decisions had in battle to be attained by shock action.

"With the introduction of firearms the manner of combat changed.... The aeroplane has not eliminated surprise nor has it given one contending nation advantage over another, since aircraft are common to all nations. Tactically, until the past year, little change has come as a result of the employment of the new science in war.... In the early days of the war it was found necessary for the low-flying aeroplanes of the period to keep to high altitudes, if reasonable immunity from gunfire was desired.... When, however, the efficiency of the aeroplane was greatly increased as a fighting machine, a few pilots of adventurous spirit made deliberate attacks on infantry in the trenches from levels well below 1,000 feet. I believe that the first attacks of this nature made in any strength were in the Battle of the Somme in July and August, 1916.

"It was found that in consequence of the high speed attained by these machines, and of the dissemination of natural apprehension among the surprised enemy, the casualties among aviators so employed were so low as to justify continuance of the prac-

tice. Hence, during the past eighteen months, no engagement of note has passed without constant and well directed use of the aeroplane as the newest form of shock action.

"This method of attack is a serious menace to infantry advancing in action. Infantry in these more spacious days, unless coherence is to be lost and the fruits or local success thrown away, must advance in some manner of massed formation. Thus a broad and easy target is laid out for the attention of the aviator. . . . The enemy artillery is unable effectively to defend the infantry in view of the heavy casualties which will consequently be inflicted on his own troops. The infantry must therefore attempt to defend themselves by rifle and machine gun fire. Harassed, as troops advancing to the attack must necessarily be, by their entrenched enemy, apart from the menace of their aerial foes, it is not probable that they are able to inflict any serious damage to airplanes passing over their heads at a speed of between 80 and 120 m.p.h."

In these days, I may remark, the speed is anything between 200 and 300 m.p.h. The fire power has gone up from two guns firing at about 600 shots per minute to eight guns firing at about 1,200 shots per minute. Major Whitaker continues:

"An army engaged in the attack on enemy positions, must take into consideration warfare in a third dimension, and must adopt formations least vulnerable to fire from above. Aeroplanes and infantry in cooperation may also take the offensive provided that the initial advantage is gained. There is no answer to these tactics, save to counter the attack by aeroplanes."

That, I think you will agree, showed remarkable foresight and a keen appreciation of the situation, considering that it was written twenty-three years ago. Whitaker himself was fond of saying that the principles of war do not change, only the manner of it changes. The study of von Clausewitz, translating his principles into terms of the air is well worth while.

These remarks of Major Whitaker's are particularly apposite because during 1918 the ground attack or ground strafing airplane, definitely a combat airplane and a most important type, was developed in Germany and in England, but the type was

never built or used in quantities. And between wars the type has been completely neglected.

Even the Germans, who have shown considerable foresight, although they have developed ground attacks by dive bombers, have not produced a genuine ground strafing airplane for close attack on infantry, cavalry and tanks.

Remember, the Germans and the Russians have both developed the cavalry arm very largely. In the Spanish Civil War, particularly good service was done by the cavalry in clearing and holding country in which tanks could not operate and infantry were too slow. General Monasterio, G.O.C. all the Nationalist Cavalry, proved himself and his men and horses to be an indispensable factor in winning the war.

Brigadier General H. J. Reilly, late U. S. Cavalry, then residing in Paris, paid many visits to Spain during the Civil War, and wrote highly enlightening articles on the uses of airplanes in ground attacks and on the use of cavalry.

When the Germans occupied Paris in 1940 an American newspaper man, describing their entry, said that the Parisians expected to see columns of mechanical robots, "Instead of which", he wrote, "they saw mile after mile of rosy-cheeked Austrian and Bavarian farm boys on fat sleek horses." Cavalry and ground attack airplanes can do much in cooperation.

That I think is a fitting close to the year 1917.

THE LAST YEAR OF THE LAST WAR

The year 1918, besides being the end of the so-called Great War, or World War I, which at this distance looks such a small affair compared with the present war, also saw the first use of an Air Force as a separate arm, independent of the Army and Navy, but cooperating with each and supplying to each men and materials, not necessarily according to the needs of the Services, but so far as the Air Force could spare men and materials from its own operations.

In January 1918, Lieutenant General Hugh Trenchard, who had taken command of the R.F.C. in France early in 1916, had rebuilt its morale after the Fokker Scourge of 1915, and had given it supremacy in the air by the end of 1917, was recalled

to England to become our first Chief of the Air Staff. He resigned in April and was appointed to form and command the Independent Air Force, to wage unlimited air war on Germany from a base in Eastern France. His work was all bombing and he had no fighter squadrons. But his bombers fought many combats, and the historical fact of the formation of an Independent Air Force should be noted.

During the year 1918 there was little advance in the design or equipment of combat airplanes used in the war. Actually the advance in the design of airplanes and more particularly of aero-motors in 1918 would have come into full force in 1919.

Such advance as did appear, was caused chiefly by the appearance of two quite remarkable motors. One was the Bentley Rotary which was a development of the Gnôme, Le Rhône and Clergêt by W. O. Bentley of the Air Department of the Admiralty, who after the war designed the Bentley racing cars. It gave 220 h.p. and had a weight of 1.9 lb. per h.p. The other was the A.B.C. Dragonfly which gave 340 h.p. for a weight of 1.765 lb. per h.p.

At the end of 1917 the best German engine had been the 260 h.p. Mercédés-Daimler at 4.36 lb. per h.p.—hardly suitable for a fighter. The 250 h.p. Rolls-Royce Falcon, and the 350 h.p. Rolls-Royce Eagle, although magnificent engines, were considerably above the 2 lb. per h.p. in weight. So one can imagine the difference which these ultra-light motors were going to make to combat airplanes.

The Bentley Rotary was promptly taken up by the Sopwith Co., who with it turned out the Snipe single-seat fighter, which could climb to 10,000 feet in 9 minutes 25 seconds and had a speed at the height of 120 m.p.h. It was much faster near the ground, because in those days we had no superchargers, and consequently our speed did not go up as we went higher. This was particularly successful as a pursuit ship against German bombers and also as a night fighter.

The Dragonfly was one of the minor tragedies of the war. Had it been produced sooner and had there been time for development, it might have put us ten years ahead of where we are now with fixed-cylinder radial motors. It was designed by

Mr. Granville Bradshaw of A.B.C. Motors, Ltd., of Hersham, Surrey. The firm had been making motors of various types, mostly for motorcycles and cars, since 1912. And the Dragonfly did give the power claimed for it at the weight. But the trouble was that it did not "stay put". Something always blew up after about 2½ hours. Consequently nobody could rely on it for long distance operations.

At that time Sir William Weir, later Lord Weir, the big Glasgow engineer, was Air Minister in our new Air Ministry. He decreed that the A.B.C. should be built in thousands, for he argued that a single-seat fighter need only be on patrol for 2½ hours, and that the engine could be changed as soon as it came back from patrol, so long as it had enough cylinders working to get it back. His action was justified thoroughly by the astonishing performance which was got out of new fighters equipped with the Dragonfly.

Another Sopwith machine which did a lot of good work during 1918 was the Dolphin. It was designed on lines quite different from any of the others. It had a Vee-type water cooled Hispano-Suiza motor of 200 h.p. The centre section of the upper plane was cut away and the pilot sat with his head between the front and aft spars. It carried two synchronized guns which could also be pointed upwards like the swinging gun in the Nieuports.

Many of the Dolphins were fitted with Sunbeam Arab motors which were practically an English-built version of the Hispano-Suiza. These engines gave a lot of trouble and one squadron which I knew well made a custom of replacing all the engines of each formation as soon as it came in from patrol. The engine was taken to pieces in a first class workshop which the commanding officer had laid out in a sugar factory in France, right alongside the aerodrome, so the machines were always ready to go up again next day.

This quick replacement of engines was no doubt what persuaded Lord Weir that the A.B.C. Dragonfly engine ought to be a practical proposition if arrangements were made to change it after each patrol.

Just what were the particular virtues of the Dolphin I could never discover, because although it was a shade lighter than the Sopwith Snipe it was only about half a mile an hour faster, but it could climb 10,000 feet in 12 minutes against the Snipe's 15 minutes 25 seconds.

There was a legend that if a pilot did a bad landing and turned the machine onto its nose the upper wing shifted forward and cut his head off where it projected between the front and rear spars. Another pleasing habit of the machine was setting the air-screw on fire. The Sunbeam Arabs, and the Suizas drove the air-screw through reduction gear. We knew less in those days about gear cutting than we do now, and the gears used to get redhot and set fire to the hub of the air-screw. And yet there were pilots who liked flying the Dolphin, and No. 23 Squadron did very good work with them.

A remarkable airplane made by the Sopwith Co. during 1918 was the Salamander. In general outline it was almost exactly like the Snipe. But it was designed primarily for ground strafing. The chief feature about it was that the cockpit and the petrol tank were quite heavily armoured so that it could safely dive into machine-gun fire on the ground and fly along regardless of hits. The assumption was I presume, that if a few bullets hit the air-screw they would either go through it or be swept aside. But obviously a blast of machine-gun fire straight into the air-screw would wreck it and force the pilot to land.

It carried two synchronized guns on the top of the fuselage firing through the air-screw, and therefore could only attack troops on the ground by diving at them as is the custom today. Admittedly it was not so far ahead of its time as was the Junkers ground strafer described hereafter.

I have never been able to discover whether Salamanders were regularly used by squadrons as ground strafers. It was faster than the Snipe, 125 m.p.h. against 121 m.p.h., but because of the weight of its armour it had a much slower climb.

It was a good idea and it ought to have been the beginning of the regular development of ground strafing airplanes. But for some curious reason, in all the air forces of the world, the

ground strafer is the one type which has been completely neglected. Although some types are called "ground attack" planes they are not up to flying through modern ground fire from Bofors guns, or 37 mm. or .5 inch machine guns.

The Junkers ground strafer was an all-metal biplane, covered with the familiar Junkers corrugated aluminum. The pilot aimed the machine, and inside it was a battery of sixteen machine guns, four by four, pointing downwards and forward through the bottom so that their fire raked the ground when the machine flew level. A man inside kept the guns loaded. The pilot could fire 4, 8, 12 or 16 at a time as he wished.

GROWING SPEEDS IN 1918

Towards the end of the War 1914-18 speeds were growing considerably. Several airplanes were built and properly flight-tested not long before the Armistice which were very much faster than anything which was used on active service. For example the Armstrong-Whitworth Co. of Newcastle-on-Tyne produced a machine called the Ara with the A.B.C. Dragonfly motor of 340 h.p. which did 150 m.p.h. And the Austin Co. produced a two-seater with a Dragonfly which did 130 m.p.h. The British Aerial Transport Co., whose chief designer was Fritz Koolhoven, produced the Bantam, with an engine of about 200 h.p. which could do 110 m.p.h. and the Basilisk with a Dragonfly of 340 h.p. had a speed of 162 m.p.h. which was phenomenal in those days.

A Bristol Scout fighter produced towards the end of the war with a 200 h.p. Sunbeam Arab did 138 m.p.h. and I find that the Bristol monoplane, to which I referred earlier, had a speed of 130 m.p.h. with only a Le Rhône motor of 120 h.p. It certainly was one of the best machines of its day.

Those who fancy that the all-metal airplane is quite a modern idea may be interested to hear that right at the end of the war, too late for it to go on active service, Captain Frank Barnwell of the Bristol Company built an all-metal version of the famous Bristol Fighter. It was built of steel tubes but the whole fuselage was plated with aluminum. The wings and control surfaces were built on steel frames and covered with fabric. With

a Wolseley Viper eight-cylinder water cooled engine it did 110 m.p.h. which was remarkably good for the power it used.

Another which would have done remarkably well if the war had gone on another six months was the Martinsyde F-4 with a Hispano-Suiza 300 h.p. motor. It did 145 m.p.h. and climbed 5,000 feet in three minutes. It was generally regarded as the best machine built during the war, and but for official obstinacy would have been in production, and largely in service with squadrons in June 1918. Five years after the war one of the remaining F-4's was fitted with a radial motor for which it was not intended and was then faster than any single-seat fighter in regular service in the R.A.F.

The reason why it was not ordered in time to be used in the war was a mixture of jealousy among designers, and obstinacy on the part of the official technical people. In all wars there have been examples of first class materials being similarly turned down and lives lost through just such causes.

Yet another very good machine which never had its chance was the British Nieuport Nighthawk, designed by Mr. H. P. Folland who had designed the SE-5a at the Royal Aircraft Factory. This had an A.B.C. Dragonfly motor of 320 h.p. and did 151 m.p.h.

Lastly, alphabetically, Vickers, Ltd., the great armament firm, built a tractor biplane with an Hispano-Suiza motor of 300 h.p. which did 147 m.p.h.

Another interesting machine was the Vickers Vampire, a small single-seat pusher, designed primarily for trench fighting, or ground strafing. In general appearance it was very like the FE-8 a pusher with the air-screw in the tail boom. It had a B.R.2. rotary motor of 200 h.p. and it had a speed of 121 m.p.h. which was very good.

FRENCH ECCENTRICITIES

In France in 1918 by far the best fighter was the new version of the Spad. This had the new 300 h.p. Hispano-Suiza motor. The original design had been modified by M. Herbemont. The speed of the new Spad was 140 m.p.h.

The other French makers seemed singularly devoid of ideas, except some that were so eccentric that they achieved nothing. The least eccentric was a Morane biplane which had a 420 h.p. Bugatti motor the peculiarity of which was that it really consisted of two engines placed vertically side by side, each driving its own crankshaft, which was geared to a central air-screw shaft. It was in fact like the top half of the modern H-type motor such as the Napier Co. make. I have no official performance figures for it but it was reputed to be fast.

Two really eccentric airplanes are worth mentioning because they did show a slight effort to get away from convention. One of them, the Moineau, designed and built by a pilot who had been famous in the early days of French aviation, had a fixed-cylinder water cooled Salmson motor placed edgewise in the fuselage with the crankshaft running thwartwise to the airplane. A shaft projected at each side between the planes and drove a tractor air-screw on each side of the fuselage through bevel gears. There was a sort of pulpit in front of the engine, and another gunner behind the pilot.

The other machine, called the Vendôme, also produced by one of the earliest French experimenters, was still more eccentric. It had two Monosoupape Gnome motors, placed edgewise, one on each side of the fuselage, and revolving in opposite directions so that the gyroscopic force of each engine cancelled against the other. As in the Moineau the edgewise engines drove tractor-screws through bevel gears. This also had a pulpit in front for the front gunner and an ordinary gun position aft of the pilot. It was at any rate a praiseworthy attempt to produce something new in twin-motor combat airplanes.

GERMANY IN 1918

In Germany one of the best achievements in 1918 was the D.V. Albatros which had a beautifully streamlined fuselage. The tail planes and fins were blended nicely into the fuselage. With the high-compression 200 h.p. Mercedes engine it did something about 140 m.p.h.

Towards the end of the war an Albatros D-XI appeared. It had a rotary motor, and its peculiarity was the fin and rudder

which were placed on the fuselage well in front of the tail plane and elevator. Evidently this was an attempt by some German designer to improve the manoeuvrability of the machine for fighting purposes, and incidentally perhaps to stop the vice of spinning. Within quite recent years several experienced designers have got hold of the idea that by putting the fin and rudder forward one can prevent the action of the rudder from being blanketed by the tail plane and elevator if the machine starts to spin.

Anthony Fokker's last war machine, the D-7, was quite one of the most advanced designs in any country. It was in fact a cantilever biplane. It had inter-plane struts but they were made of quite small steel tubes arranged in the shape of the letter "N" wrong way round. The object of these struts was to keep the upper and lower planes parallel with one another, and to stop the wing tips from twisting, and possibly fluttering. Also, the upper plane to some extent carried the lower plane and the fuselage suspended below it, for it was not fixed directly onto the fuselage but attached some six inches or a foot above it by a series of steel tubes.

Thus most of the weight of the machine was carried in suspension on steel tubes from the upper plane. The lower plane was built into the bottom of the fuselage and there formed a cantilever of normal type.

I see that the British official figure for it is only 116.6 m.p.h. at a height of roughly 3,300 feet. It is unexpectedly slow for any single-seat fighter with a Mercedes motor. Certainly our aviators who fought it found it a very fast airplane. Possibly the speed at ground level might have looked better by comparison with the speed of British and French machines? In those days, when there were no supercharged motors to maintain their power at considerable height, airplanes did definitely fall off their speed very quickly as they climbed. Hence the fact that an airplane which was supposed to do 116 m.p.h. might very well have been reckoned to do 130 at ground level.

Anthony Fokker also produced a "Parasol" monoplane in which the wings were carried on steel tubing above the fuselage

without any of the struts and wires which had hitherto been used in the Parasol type. It never did much in the war but as an engineering structure it is interesting.

An original idea was struck by the designer of the Brandenburg seaplane fighter. In practically all fighters up to that period the gunner's arc of fire was interrupted by the fin and rudder. A check stop was fixed to the gun-mounting or gun-ring so that the gun could not be moved into the area covered by the fin. And if an attacking pilot were clever he could by dodging about behind the tail distract the gunner's aim and force him to bring his gun up against the check protecting the fin from his own fire.

The Brandenburg got over this by the simple process of putting the fin and rudder underneath the tail-plane so that the gunner could sweep the whole circle without interruption. It may have looked good but it did not work out so well aerodynamically.

In 1918 appeared the first of the famous Junkers airplanes. Dr. Junkers was a well-known engineer, and before the War 1914-18, was chiefly famous as a maker of heating apparatus, especially electric geysers for household use. In 1917 a new firm was formed by Dr. Junkers in conjunction with Anthony Fokker. It built all-metal airplanes to Fokker's design. The wings were, in nearly all except the earliest machines, built of corrugated aluminum.

People scoffed at them because they looked like a corrugated iron shed. But Fokker's experience and Dr. Junkers' engineering ability built some quite remarkable airplanes, from single-seat cantilever monoplanes to very big two-seaters which had a comparatively small lower plane and a very big plane on top. I have already mentioned the sixteen-gun ground strafer.

Another good German fighter, which American pilots of the last war will remember, was the Pfalz. It was built on small orthodox biplane lines but it was very light and the design was clean and it had a good performance and comparatively low horsepower. And it was a very manoeuvrable fighter.

Another interesting point about 1918 in Germany is that the great Zeppelin Airship Co. started to build airplanes and built

a novel biplane fighter. It had no struts between the lower and upper wings as had the Fokker and each was fixed separately to the fuselage, so that the machine was a true double cantilever.

AMERICAN NOVELTIES IN 1918

In the United States the Curtiss Co. built an interesting experimental single-seat fighter with a Curtiss 400 h.p. Vee 12 motor. Unfortunately I have no reliable figures for its performance.

Another good idea was a monoplane with a 300 h.p. Hispano-Suiza motor, built by the Loening Engineering Corporation. I find a record that on test at Mineola, Long Island, it did the high speed of 146 m.p.h. and that it climbed to 24,000 feet in 42 minutes with pilot and passenger, two hours' fuel, and gun equipment. The upper wing was level with the top rail of the fuselage so the pilot had little view downward when landing. But when in the air his view was excellent.

Searching through the history of 1918 I find record of a curious little machine built by Captain J. V. Martin of Elyria, Ohio. He was a sea captain by trade who had learned to fly at the Grahame-White Aviation Company's School at Hendon, near London. He claimed to be the inventor of the retractable undercarriage, which has probably done more than any one alteration in design to put up the pace of the modern airplane. Whether Martin's claim to a patent on the retractable undercarriage has been substantiated or not, the fact remains that I can find no record of any machine with a retractable undercarriage before his in 1918. Captain Martin also claimed to be the patentee of the K-shaped inter-plane strut, which he called the "Kay-bar" strut.

During 1918 J. V. Martin built a twin-motor bomber with two 400 h.p. Liberty engines, which were contained inside the fuselage and drove tractor-screws through gearing. This is of interest because there is a definite tendency in these days to put the engines completely inside the fuselage and drive through gearing. Lawrence Bell has done it with the Airacobra and there are various makes of high-speed machines which will have the engines inside so that the air-screws must be driven through gearing outside. The drawback to them obviously is the amount

of power which must be wasted in gearing. But the problem to be proved is whether the losses in the gearing are as high as the losses caused by sticking the engine out in the open. I shall return to this subject later on.

Another interesting fact in 1918 about combat airplanes built in the United States is that the Packard Motor Co. built during 1918 one of the finest two-seat fighters produced up to that date. It was designed by Captain G. Lepère of the French Air Service who was on special duty in the United States. It carried two guns forward and two guns aft and had an ingenious system of inter-plane struts which seemed likely to give it a very good streamlined effect.

It was, so far as I can discover, the only actual fighter designed round the Liberty motor. Its speed was 136 m.p.h. low down, and it climbed to 10,000 feet in 10 minutes, 35 seconds. Its service ceiling was 20,800 feet, and two of it were the only U. S. combat planes which were used in France.

This I think is the proper point at which to say something about the Liberty engine. Although we are primarily concerned with combat airplanes and the Liberty was not used during the war in fighters of any kind other than those two Lepères, it was a remarkable achievement. It was designed jointly by Mr. J. G. Vincent of the Packard Co. and Mr. G. E. J. Hall, the chief engineer of the Hall-Scott Motor Car Co. of San Francisco. The idea was that an American engine of high power should be mass-produced and that airplanes of various types should be designed round it.

The story at the time was that Mr. Hall and Mr. Vincent locked themselves up together and set to work designing the engine, and that the designs were completed after thirty-six hours of non-stop work.

The probable truth is that these two very capable engineers did get together and have a practically non-stop session for thirty-six hours, most likely with an interval for rest and refreshment, and that at the end of it they had the general layout of a 400 h.p. water cooled twelve-cylinder Vee-type engine, after which, working together, they handed over detail designs to selected members of their staff.

Anyhow, the fact remains that the Liberty, although it was heavy for its power, and therefore unsuitable for high-speed fighters, turned out to be about the most reliable power plant that the world had seen up to that date. It was used for years in the transcontinental air mail ships which were run by the U. S. Post Office until 1925. Still later than that it was used as an effective if not efficient maid-of-all-work in the R.A.F. DH-9a which did all the air police work in the R.A.F. in India, Iraq, and Africa, except what was done by the left-over Bristol Fighters with Rolls-Royce engines.

Yet another American fighter which unhappily arrived too late to be of use in the war was the Thomas-Morse M.B., which with a 300 h.p. Hispano-Suiza had a speed of 124 m.p.h. and a landing speed of 55 m.p.h. It was one of the most efficient all-round tractor biplanes of the time.

With the end of 1918 and the Armistice came the end of the active production of warplanes. And we may well consider the Armistice as marking the end of an epoch in the evolution of combat airplanes.

In the next section of this discussion we will consider how combat airplanes developed during the twenty years of approximate peace.

Part II

EVOLUTION BETWEEN WARS

When peace broke out the fastest combat airplanes in use over the fighting line were doing between 125 and 135 m.p.h., but the bulk of them were doing between 90 and 110 m.p.h.

Another point to be noted is that in those days the speed of an airplane was fastest at ground level. As an airplane went higher and atmospheric pressure became less there was less air forced into the cylinders, and so, though the head resistance, or drag, of the machine grew less as it got into thinner air, the power of the engine died away.

Already before the Armistice a few ingenious motor car designers were supercharging their engines by driving air, impelled by a fan, into the cylinders at more than atmospheric pressure of 15 lbs. per square inch. And some aero-motor designers were thinking along the same lines.

When supercharging was introduced two methods were developed, each by several firms. One was to drive the fan by a turbine driven by the exhaust gases from the engine itself. Thus the unexpended power of waste gases was used to pump more air into the cylinders to produce more power and more gas.

At first sight this appears rather like standing in a basket and trying to lift yourself by the handles, or any other kind of perpetual motion. But actually it is merely an efficient way of using waste material, just as during the war we used to drive the power plants of our aircraft factories with gas engines driven by gas which was made from the waste timber from the woodworking shops.

The point is that all engines are very inefficient if one considers the potential power stored in a given quantity of gasoline. There is still a lot of waste power stored up in the exhaust gases which are expelled, not *exhausted,* from the cylinders. To use these gases to drive a turbine or a blower is only getting some of the waste material back.

Another method of supercharging was to drive the blower through gearing off the main shaft of the motor. Naturally,

delicate design was needed to assure that the blower would only blow so much air as was needed into the cylinder. Anything more would be again wasting power.

Consequently, one of the first developments in supercharging was to use a two-speed blower which would run at a comparatively low speed while the airplane was low down, and the air was comparatively thick, and would be speeded up to drive more air when it was higher and the air was thinner.

After this came the two-stage supercharger, in which at medium height, when the air is fairly thin, the first stage of the blower can be used, and when the machine reaches a great height and when the air is very thin, then the second stage is used and the air which is received from the first stage is still farther compressed when being blown into the cylinders.

The result of all these arrangements is that even at 40,000 feet, where the air is so thin that air crews cannot live by flooding their faces with oxygen, but must have either pressure cabins or pressure suits, to force the air into their lungs, the superchargers are keeping the engines well supplied with needed air.

This supercharging would have been of little use itself if nobody had invented variable pitch air-screws. By increasing the angle of the air-screw blade to the air the variable pitch screw is enabled to absorb the artificially produced power of the motor and can itself deal with enough of the thin air to pull the machine along at a much higher speed than it would reach low down.

The net result of all this is that when a modern airplane reaches a great height and is in very thin air it has to fly faster to keep up, and it is enabled to fly faster by the variable air-screw and the supercharged motor. Which is why the speed of the modern combat airplane at great height is so much more than it is at low level.

I give this bit of information on superchargers and gears because if the idea is generally understood I shall be able to refer to it and speed at height as we proceed to discuss the development of fighters between wars.

About 1920 most of the aircraft firms either turned their attention to building civil airplanes, or went out of business alto-

gether, while the proprietors of others pouched their profits and changed over to more profitable business.

There is all the more credit to those firms and individuals in all countries, who, having made profits out of the war, had faith in aviation and the courage to stay in it and improve airplanes whether for peace or war. So let us go on with their development.

NIGHT FIGHTING

Going back to my documents of 1919-20 I find that at some time unspecified, probably in 1918, the Royal Aircraft Establishment, formerly the Royal Aircraft Factory, at Farnborough, produced a weird-looking thing called the N.F.E. which meant "Night Flying Experimental". This had a Hispano-Suiza motor of 200 h.p. It had a span of 47 feet 10 inches which was quite sensible. The upper plane was right down on top of the body, or nacelle, and the pilot and passenger thus sat level with and in front of the top plane, so that they had a magnificent view all round and upwards and downwards. In fact their view was more than three-quarters of a sphere, which was good. The machine carried a searchlight in the nose, and guns which fired over it.

This machine is interesting because of the importance of night fighting today. In fact it might have been made the basis of a special type today but for the fact that we have already progressed to the stage at which eyesight in a fight with enemy machines is unimportant, because an attacking machine carries instruments or a "device", as our Air Ministry communiques call it, which do for the night pilot far more than his eyes could do.

I may digress here again to say that there had been a great deal of night fighting during the War 1914-18. In fact our night fighters had proved so successful that on May 19, 1918, the German raids on Great Britain ceased. For this we had to thank Major General E. B. Ashmore of the R.A.F. and R.F.C. (formerly R.A.), who was appointed General Officer Commanding the London Air Defence Area early in 1918. He developed the kite-balloon aprons which kept the enemy raiders up above 8,000 feet, and a highly efficient gun barrage which kept most of the raiders above 14,000. The rest of the sky was open

to the night fighters, which were either Snipes or Camels or SE's, but mostly Camels.

In those days we had no scientific devices to find enemy night raiders. But it was quite simple for our pilots. When an enemy came over it was generally picked up by the searchlights, after which it was shelled by the barrage. The night fighters, cruising round looking for trouble and seeing a lot of shells in a particular part of the sky, concluded there must be an enemy aircraft in the searchlights somewhere about there, so they used to fly straight to that point, dive in among the shell bursts, taking the chance of being hit themselves, and try to find the enemy raider in the searchlight beams.

The number of times they were successful and the small number who were hit by our shells was remarkable. I may say that in those days there was no particular scientific training for night fighting. They were not fed on special vitamins, they were not required to sit for hours in the dark before going on night flights. And they had no radios to help them back to their own aerodromes. Above all they had no parachutes, so if they were irretrievably lost on a pitch-black night they had to feel for the ground with their wheels. And yet the number killed was astonishingly small.

CANNON FIGHTERS

Here I will allow myself yet another digression from the strict story of the evolution of combat airplanes. Some time early in 1918 the Hispano-Suiza people produced a special form of 300 h.p. motor, the camshaft of which ran along between rows of cylinders at the bottom of the Vee, and was made big enough to let the barrel of a machine gun into it. Thus the pilot was able to fire through the centre of his air-screw without being bothered by interruptor or synchronizer gears.

Then the Hispano-Suiza people went one better and made a quick-firing gun which fired a 20 mm. shell which burst on contact. This was, authentically, the first cannon gun.

Very few of them had been made and tested before the Armistice. Three of them were committed to the care of three outstanding pilots, Guynemer, Nungesser, and Fonck. The story at the time was that Guynemer fired his gun three times

and brought down three German machines, but the fourth time the gun burst and blew half his face off.

There is no record of what Nungesser did with his gun, but he was a magnificent shot so he must have done some good trade.

Fonck, who was probably the deadliest shot in the French Service, and had brought down more Germans than anybody else, used his air cannon quite considerably. And the story was that every time he fired he brought down an enemy. That is rather a big claim, and so far as I can discover no figures have been published. But certainly his gun was effective.

SOMETHING NEW IN MOTORS

To continue now about the evolution of fighters:

The last year of the war had seen the production of the Dragonfly of 300 h.p. While this was going on a young man named Roy Fedden had been working at Fishponds, near Bristol, with a firm called the Cosmos Engineering Company which made a radial air cooled engine with fixed cylinders called the Mercury.

During 1919 these designs were taken over by the great Bristol Co. and already the Bristol Jupiter of 450 h.p. had appeared. It was fitted into a Bristol biplane called the Badger which was taken over by the R.A.F. and was the ancestor of a whole series of Bristol biplane fighters. The Jupiter and its successors, the Mercury and the Pegasus grew more powerful for about twenty years. And just before the war in 1939 the twenty-fifth modification of the Pegasus was giving just about 900 h.p.

A step forward towards present day custom, or fashion, was made in 1920 when Boulton & Paul Ltd. of Norwich, and Short Bros. of Chatham first made all-metal airplanes. They were in fact built exactly on the lines of wooden machines but aluminum or duralumin was used in place of timber. The Boulton & Paul machine was covered with fabric, but the Short had duralumin sheeting on wings and control surfaces. It was, I imagine, about the first all-metal machine except for the Junkers of 1918.

Neither the Germans nor the French produced anything new in the way of fighter machines during 1919, the French because

they were sick of war, apparently, and the Germans because they were not allowed to build anything new of a military nature. In the United States the pall of peace also descended on the development of fighters.

A MATTER OF DIESELS

In the preface to my annual "All the World's Aircraft", writing in March, 1922, I remarked of aero-engines of the world, "Here, unfortunately, there is little progress to record, . . . Where lamentable lack of progress is shown is in the fact that nothing has been done worth mentioning to produce a new engine using either paraffin or heavy oil, for in this direction alone, and not in crash-proof tanks or in parachutes, lies the true solution of the problem how to prevent fire either in the air or in a minor accident on the ground."

There is no pilot today who does not lament the fact that in the twenty years between wars nobody has developed a Diesel-type heavy-oil motor free from the possibility of fire and from all electrical gadgets and carburetor troubles.

When one considers the hundreds of millions, probably by now thousands of millions, of dollars and pounds, and other currencies, which have been wasted on producing airplanes of what we are pleased to call modern types, one is less surprised at the general lack of intelligence among human beings which allows wars themselves to be possible.

One of the greatest of the world's aero-engine designers told me five or six years ago that given a quarter of a million pounds, say a million dollars at the present rate, he would guarantee to produce a Diesel aero-motor which would in every way equal the present day gasoline motor. Such an invention would be a benefit to humanity not only in war but in peace.

And it would reduce the cost of air transport greatly, not merely by reducing the price by the difference between heavy oil and high grade gasoline, but in the manufacture of the motors, their repair and maintenance.

That same designer had already, somewhere in 1936 or so, produced an air cooled radial Diesel motor which in the ratio of weight to horsepower was equal to any radial aero-motor built

until about 1925. From that, I can judge, only a small amount of extra expense and effort was needed to bring the Diesel motor up to the state of efficiency of the most modern gasoline motor.

DESIGN FOR MASS PRODUCTION

In 1921 a Company called Sir W. G. Armstrong-Whitworth Aircraft, Ltd., was formed. It represented the aircraft interests of the great Armstrong-Whitworth shipbuilding Company of Newcastle-on-Tyne which had built airplanes during the war. These rights had been acquired by Sir John Siddeley whose Siddeley Motors, Ltd., was one of the best-known firms in the motor trade and already made the Siddeley Puma aero-motor.

Thenceforward Armstrong-Whitworth aircraft were built at Coventry in conjunction with the Siddeley Co.

Anticipating history somewhat I may add that this was the company which was later brought into the Hawker-Siddeley combine and made the Armstrong-Whitworth Whitley bombers which are so well known to the Germans.

The first product of Sir W. G. Armstrong-Whitworth Aircraft, Ltd., was the Siddeley Siskin, a single-seat fighter with a Siddeley Jaguar radial motor of 300 h.p., an engine which had been produced to rival the Bristol Jupiter, but never quite did.

Nevertheless the Siddeley Siskin marked a step forward in the design of combat airplanes. The first were built of wood but later on they were built on a metal framing covered with fabric, which framing was made not of aluminum but of steel strips, very similar to large umbrella ribs.

It was the first attempt to put up a steel-built fighter in competition with timber or aluminum. The Siskin was good enough to remain for many years as the first-line single-seat fighter of the R.A.F.

Sir John Siddeley, now Lord Kenilworth, acquired this umbrella rib patent because, although producing the parts in small quantities was very costly, if they had been needed in war, as now, they could have been turned out by the mile at speeds which would have shaken the preconceived notions of mass-producers in other trades. But now we use other methods and materials, some definitely less quick and simple to mass produce.

THE HANDLEY PAGE SLOT

Many people who are qualified to judge would say that the greatest step forward in European aviation in the year 1920 was the introduction and development of the Handley Page Slot. This was made known to the world in the *Aeroplane* newspaper in March, 1920. And it is still not used as it should be.

Briefly the Handley Page Slot is formed by a slat, like that of a venetian blind, but curved to an aerofoil section, which when at rest is closed back against the wing and becomes the leading edge of the aerofoil. When the airplane is climbing, or when the pilot is sinking it with the tail down and the wings at a coarse angle of attack to the air, the slat shoots forward, because of the pull of the air on the leading edge, and opens a slot between it and the main portion of the wing, or aerofoil. This leads the air smoothly over the upper surface of the wing and prevents it from stalling. When the slats are fitted to the wing tips only, and the middle portions of the wings stall, the air flows smoothly over the tips and gives proper control of the ailerons.

The slat-and-slot was invented and patented in Germany by Dr. Lachmann, a pilot of the War 1914-18, almost at the same time as it was invented by the experimental staff of Handley Page, Ltd. The German Patents Office refused to grant a patent because they do not grant patents to anything which has not proved that it would work. And they did not believe in the slot theory.

Consequently the Handley Page slot was patented in England before Dr. Lachmann patented his in Germany. But his application for patent might have constituted "prior publication" and so Mr. Handley Page very wisely bought out Dr. Lachmann and added him to his staff. From then until the outbreak of war Dr. Lachmann's high ability was used for the improvement of British aircraft. On the outbreak of war, as he had neglected to take out British naturalization papers, although resident in the country for most of twenty years, he was necessarily interned.

One of the first uses to which the slot was put in this country was when Air Commodore Adrian Chamier came back from

India, where he had been using Bristol Fighters on the frontier, and was appointed Director of Technical Development at the Air Ministry. He promptly ordered that all Bristol Fighters should be fitted with slots.

During the War 1914-18 the Bristol Fighter lightly loaded with nothing more than ammunition and a few bombs and gasoline for a rather short patrol, was a delightful machine to handle. But after the war when used as maid-of-all-work in India and Iraq and in Africa, loaded with more gasoline than usual, full armament, cases of beer, barrels of water (in case of landings in the desert) and other baggage, and flown in hot air from which all the lift had evaporated, the Bristol was apt to stall viciously and spin into the ground. The fitting of Handley Page slots to wing tips assured that at any rate the pilot could bring the thing down on a level keel, thereby saving many lives.

The slot was also fitted to the Armstrong-Whitworth Atlas, a later two-seat fighter which, before the slots were fitted, had a particularly vicious habit of stalling and spinning.

Later again they were adopted by the U. S. Navy which paid a large sum to compound, or commute, all the royalty payments. At one period, on which I will touch when we get there, considerable controversy arose in the United States about the slots between the Curtiss Co. and Handley Page, in a safety competition originated by Mr. Harry Guggenheim.

Quite recently slots have been used on the big Savoia-Marchetti Italian bombers which, when they appeared, were on proven figures the most efficient bombers in the world, and still hold the world's record for long distance and duration with a load of 1,000 lbs.—roughly 8,000 miles in 56 hours—enough to bomb New York from Europe.

And, a peculiarly interesting point, slots are used by Willy Messerschmitt on his high-speed single-seat fighters to give them a chance of landing slowly.

So far as I know the only other airplanes to which slots are fitted at the time of writing are the Westland Lysander, an Army Co-operation monoplane which gets off and lands astonishingly slowly, and the Handley Page Hampden, on figures our most efficient heavy bomber until 1941.

I have put this section about the slot in at this stage of the history because an understanding of what they do and what they have done simplifies references to them later on.

EVOLUTION IN 1921

No history of the evolution of fighting airplanes would be complete without mentioning that the great Sopwith Aviation Co. went into liquidation in September, 1920 and some members of the firm founded a company called the H. G. Hawker Engineering Co. Ltd. to make motorcycles. Everybody's motorcycles had a poor time during the post-war slump of 1921, and the Hawker Engineering Co. Ltd. started to make airplanes. From that grew the long series of Hawker combat airplanes, as well as the immense Hawker-Siddeley combine which is by far the biggest thing in British aviation.

I trust that my American readers will not think that I am devoting too much space at this period to British aviation. But I would point out that at the end of the last war, the American aircraft industry was still a comparatively small affair.

Colonel Edgar Gorrell shows that very conclusively in his great work in this series, "The Measure of America's World War Aeronautical Effort," in which he shows that 1912 American-built airplanes were delivered to the American Expeditionary Force in France, and of these only two Lepères were fighters. The rest were DH-4 bombers. And the A.E.F. had 4,791 French airplanes and 261 British.

America's aircraft industry really began to grow after the war with the growth of air transport and in that sphere eclipsed all other nations. But, partly because of the enormous growth of air transport, first of all on the American continent and then by the supply of American transport airplanes in Europe and Asia, the evolution of combat airplanes was considerably hampered and somewhat slow in development. Nevertheless, as will be shown very soon, one particular line of development in fighters in the United States influenced the design of fighters all over the world.

Reference must be made here to a curious and interesting development in British aviation, which influenced the evolution of

combat airplanes. In 1919 Mr. Handley Page and Mr. Godfrey Isaacs, a brother of Lord Reading, later Viceroy of India, formed a concern called the Aircraft Disposal Co. Ltd., which paid one million pounds to the British Government and took over all the surplus stock of airplanes, motors, equipment and raw materials in the hands of the R.A.F. and arranged to dispose of it all over the world. The British Government were to take half of the profits. Altogether the Government got six million pounds out of it besides the initial one million, which was better than the price they would have got by selling the lot as scrap metal.

And as Mr. Winston Churchill, who was then Air Minister, cut the R.A.F. down to 1/10th its size, from 30,000 officers and 300,000 men, to 3,000 officers and 30,000 men, you may judge that there was some disposal.

The A.D.C. took over existing airplanes and partly finished airplanes and built them up into fighters, bombers, or whatever they were, and sold them to small nations at prices with which no new airplane could compete. The French and Italians on the other hand, sent missions, chiefly to South America, equipped with their latest types of fighters, and as a rule gave away a number of airplanes as samples, hoping to get profitable prices for any more which they might sell. But the British method seemed to work best because until, several years later, the U. S. industry started to compete by offering new types of combat airplanes, and all the old A.D.C. stuff was worn out, there were more British airplanes in the hands of the small nations than there were of any other nationality.

From the point of view of the makers of fighting machines, the A.D.C. was a good thing because it allowed small nations which had little money to equip themselves with what looked quite an important air fleet. And, when once they had got it, they were more or less bound to maintain and increase it. Also this acquisition of cheap fighters produced quantities of competent pilots in all countries, and they all wanted newer and better fighters.

Considerable advance was made in France in 1920 when the Spad people produced the M.20 bis., with a 300 h.p. Hispano-

Suiza motor, which in the Gordon Bennett Race piloted by the Comte de Romanet did 193 m.p.h. True it was a racing machine but it was a development which could have been turned into a fighter. And it definitely influenced the evolution of combat airplanes.

Another interesting development in France during 1920 was the variable surface wing produced by Gastambide and Levavasseur. Both the trailing edge and the leading edge slid, one backward and the other forward, on projecting rails or guides much like the Fowler flaps on Lockheed monoplanes of today.

Another French achievement was the Nieuport Sesquiplan, which won the Deutsch Cup in 1921 by flying at the rate of 175.2 m.p.h. for 1 hour 4 minutes 39 seconds while covering the course of 300 kilometres. Afterwards the same machine put up a world's record of 205 m.p.h., the first time that 200 m.p.h. had been beaten. So, for a change, the French began to show us something.

In Germany progress was stopped by the Treaty of Versailles and all that was done was to overhaul and patch aircraft. But among the airplanes destroyed by the Disarmament Commission was a giant Rohrbach monoplane which is interesting because the wing structure was built round a metal box much as is the custom among the best aircraft designers today.

A curious fact is that on December 29, 1921, a world's duration record of 26 hours 48 minutes 25 seconds was set up by a German-built Junkers monoplane with a B.M.W. (Bavarian Motor Works) engine, in America.

PUTTING-UP SPEED IN THE U. S.

During 1921 speed was going up in the United States. The Curtiss Navy Racer was designed in the summer of 1921 for the Pulitzer Race, which it won, piloted by Mr. Bert Acosta at an average speed of 176.7 m.p.h. It was fitted with the Curtiss B.D.-12 motor which developed 405 h.p. at 2,000 r.p.m. This is a fact to be noted because the B.D.12 had far-reaching results in air history.

Incidentally, I wonder what became of an interesting development of 1922, a Parasol monoplane built at the U. S. Naval Air

Station at San Diego, California, by Aircraft Machinist's Mate First-Class C. M. Rocheville of the U. S. Navy, in his spare time. It was built up on a Spad fuselage and it had a variable camber monoplane wing with a high top speed and a low landing speed. It was piloted by Lieut. F. C. Faken. There are ideas to be got out of failures of the past, and often the failures are not caused by wrong ideas but by lack of engineering knowledge or knowledge of materials.

In 1922-23, although we produced an amazing variety of types of airplanes in Great Britain, we produced nothing outstanding. The one thing which does seem worth recording is the fact that Mr. G. H. Handasyde, formerly of the great Martinsyde firm, built to order for Australia a cabin cruiser with a 360 h.p. Rolls-Royce engine which had a four-wheeled undercarriage, like a much improved Voisin, in which the two front wheels were much closer together than the two back wheels so that it was in fact much the same as the tricycle undercarriage about which so many people are crazy these days, except that it provided a more reliable and stable base for the machine when on the ground. The undercarriage was not retractable. But the placing of the wheels is worth studying, especially now that we are getting to high-speed two-motor fighters.

Investigating these affairs of 1922-23 discloses the fact that Handley Page built a very good single-seat fighter to the order of the U. S. Navy which, naturally, had Handley Page slats and slots all over it.

Neither France nor Germany produced anything worth talking about, but Anthony Fokker built for the U. S. Army a monoplane with a 400 h.p. motor in which on April 18,1922, Lieutenants MacCready and Kelly stayed aloft at Dayton, Ohio, for 36 hours 5 minutes 20 seconds covering a total distance of 2,541.2 miles, thus setting up a world's duration record. On May 2-3, the same two officers in the same machine crossed America from New York to San Diego, California, a distance of 2,650 miles, in 26 hours 50 minutes non stop. This, I believe, was the first non-stop flight from ocean to ocean. It has nothing to do with combat airplanes but it will serve to show the young officers of today that officers of eighteen years ago, who I hope by now hold

high rank in the U. S. Army Air Corps, were able to hold their own against the best professional pilots in the world.

THE CURTISS REVOLUTION

America's great achievement of 1922 was the Curtiss Army Racer, a very fast biplane. In one of them Lieutenant R. L. Maugham of the Army Air Service won the Pulitzer Trophy Race at Detroit on October 14, 1922 at an average speed of 205.9 m.p.h. Two machines of this sort were built to the order of the Army. These finished first and second, and two others which were built for the Navy finished third and fourth.

Four days later Brigadier-General William Mitchell of the U. S. Army Air Service, put up a new world's speed record of 224.38 m.p.h., a pretty good show for a man more than forty years of age. During the War 1914-18 General Mitchell had himself led into the air during the Battle of the Argonne in France a mixed force of American, French and British aviators which was the biggest air force which up to that day had come under one officer.

These Curtiss Racers practically revolutionized the design of combat airplanes. The Curtiss D-12 engines, which gave 450 h.p., shared with the designer of the airplane the credit for this revolution. I believe that the producer of the airplane was Bill Gilmour who in 1924 deserted his successful airplanes to go and make a fortune out of zip fasteners.

The D-12 was a very clean motor, much on the Hispano-Suiza model. But the Curtiss designers managed to streamline the engine into the fuselage in such a way that drag was reduced to a minimum. This streamlining in front together with the spinner on the hub of the air-screw gave the machine a curious pointed look which reminded people of the Eversharp pencil. That type nose has been known as the "Eversharp" ever since.

The Loening Aeronautical Engineering Corp. also produced a Pulitzer racer to the order of the U. S. Army Air Service, with a 600 Packard, and put up quite a good performance. But although it was a low-wing monoplane on extremely modern line it could not quite compete with the Curtiss biplane. Its best speed was reckoned at 180 m.p.h.

NEW BRITISH FIGHTERS

Round about this time Captain Frank Barnwell of the Bristol Co. produced a combat airplane which, although it was never developed, had an excellent idea in it. Primarily it was a high-wing or parasol monoplane single-seat fighter. But the whole fuselage aft of the pilot's seat, together with the tail unit, could be unbolted in a few minutes and another section could be bolted in, which consisted of a gunner's cockpit with a Scarff ring, and another cantilever wing built onto the floor of the section. When this was bolted in, the ordinary tail unit was bolted onto the back of it, the controls were coupled up again, and you had a two-seat biplane fighter the appearance of which was only odd because the lower plane was so far aft of the upper plane.

The idea was to provide for the air forces of small nations, which could not afford to keep a variety of types of airplanes, a standard front part, which could be used either as a single-seat fighter or for a two-seat fighter-reconnaissance machine as desired. All the spare parts were identical for the two machines, except for the gunner's cockpit and wing. Also it meant that if two or three were damaged probably one complete machine could be built out of the parts which were not damaged. For some reason the idea never caught on.

In 1923 the Fairey Aviation Co. Ltd. which was founded in 1916 by Mr. C. R. Fairey, one of the British pioneers, built its first fighter, the Fairey Flycatcher, which was designed primarily as a ship-board fighter, to fly on and off the decks of aircraft-carriers, for the protection of the Fleet. Its chief claim to fame was that it became known as the only airplane which a ham-handed Naval Officer could not pull to pieces in the air. It was not very fast but it was immensely strong. And it was fitted with flaps.

Another good British fighter of the period was the Gloucestershire Aircraft Co.'s Mars biplane, which, with a Jaguar motor of 370 h.p., had a speed of 150 m.p.h. This became known as the Gloster Grebe and was one of the standard fighters in the R.A.F. It is worthy of note here because it was the direct ancestor of the Gloster Gladiators of this war.

The only notable product in France in 1922-23 was the Dewoitine. It was a high-wing monoplane built entirely of duralumin. M. Dewoitine became famous during the following ten years for turning out the best French fighting machines. But none of them compared with the best American and British fighters, and France practically dropped out so far as combat airplanes were concerned. We saw the result sadly in the summer of 1940. The Dewoitine had a speed of 151 m.p.h. with a 300 h.p. Hispano-Suiza motor, which was not so bad.

The French produced a number of interesting and ingenious cruising airplanes, but, apart from their big trans-atlantic flying boat and some of the later air liners the French genius seemed to have departed.

Developments in Germany at this period were worth watching. Under the Treaty of Versailles the Germans were forbidden to make big airplanes or powerful motors. So they concentrated on getting the highest efficiency from quite small machines. The result was, for example, the Albatros L-60 which was a monoplane with a 70/80 h.p. Siemens radial motor and did 90 m.p.h. with a pilot and passenger. That was as much as single-seat fighters had been doing during the war. The design was evidently based upon what had been learned by gliding experiments. And the Junkers Co. were getting 90 m.p.h. out of one of their corrugated aluminum high-winged monoplanes also with an 80 h.p. Siemens motor.

In 1923 we first come across Herr Udet, as a designer. At the time of writing he is technical chief of the whole German Air Force. Udet had already made a great name for himself in Europe as an acrobatic flyer. Now he produced a beautifully streamlined little sports monoplane with a Siemens 70 h.p. seven cylinder engine and an enclosed cabin for two people, with the pilot in an open cockpit in front, which did 112 m.p.h. It was not a fighter but it is worth mentioning because it showed the lines along which the German intelligence was working.

In Holland the two great rivals, Fokker and Koolhoven, were proving that competition was good for trade. Fokker produced a C-4 two-seat fighter with a 400 h.p. Liberty motor which did 146 m.p.h. Koolhoven produced the FK-31 two-

seater with a 400 h.p. Bristol Jupiter Radial which had a top speed of 151 m.p.h. In Italy the Fiat Co. produced the first of their famous CR type, a curious single-seat biplane in which the upper plane was shorter than the lower, for no easily explained reason. With a 300 h.p. Hispano-Suiza it had a top speed of 165 m.p.h. which was truly remarkable, for even allowing that it had no guns and gunner aft, it had interplane bracing and struts.

In America the Curtiss Co. continued their triumphs. At the end of 1923 Lt. Alford Williams, U.S.N., raised the world's speed record to 256.6 m.p.h. on November 4. The Secretary of Navy stopped a further attempt on the speed record as it was becoming too dangerous.

On top of that two Curtiss CR-3's competed for the International Schneider Trophy for seaplanes.[2] One of them, piloted by Lt. David Rittenhouse won the trophy. An interesting point is that one of them had the same wings and fuselage as that which, as a land-machine, won the Pulitzer Trophy Race in 1921 piloted by Bert Acosta. These machines, in spite of floats and biplane bracings and all the rest of it did 194 m.p.h. and on tests over short distances were doing 200 m.p.h. An interesting point is that the standard Curtiss pursuit plane with a Curtiss D-12 motor giving 375 h.p. instead of the 400 h.p. of the racer, did 170 m.p.h.

There is considerable interest in noting that the Wright Aeronautical Corporation of Paterson, New Jersey, also built a Schneider Racer for the 1923 contest. It had a twelve-cylinder Wright Vee-type water cooled motor for which 650 h.p. was claimed. In general appearance the Wright racer was very like the Curtiss.

The makers claimed that the top speed was 186 m.p.h. The same machine on wheels instead of floats was said to have a speed of 240 m.p.h., with 70 m.p.h. as its low speed.

These machines had a single-inter-plane strut on each side built up more or less on the principle of the K-bar strut.

[2] This contest was flown at Cowes, Isle of Wight, England. The competitors were accompanied by the U. S. Cruiser *Pittsburgh*,—as Commander John Towers (now Admiral commanding U. S. Naval Aviation) said, "to see fair play". It was a great party.

About this time gliding became a popular sport, which reached its highest development in Germany where big airplanes were prohibited and few people had enough money to buy airplanes anyhow. The gliding movement started with a bang in England in 1922 but was killed by the introduction of the cheap light airplane. Thus we lost many valuable lessons in how to build efficient airplanes at a minimum of expense and man-power.

PROGRESS IN 1924

In 1924 the French seemed momentarily as if they were going to contribute something to the progress of aviation in general and to high-speed fighters in particular. The Société Industrielle des Métaux and du Bois built to the design of M. Bernard, a single-seat fighter with a 300 h.p. Hispano-Suiza motor which did 152 m.p.h. They also built a racer with a 450 h.p. Broad-Arrow-type Hispano-Suiza which raised the world's speed record to 278 m.p.h.

It is interesting to note that both these machines were middle-wing cantilever monoplanes. If they had been able to retract their undercarriages in modern style they would have had a truly remarkable performance. But the curious thing is that nobody in Europe up to that date, and nobody in America for that matter, had thought of following up J. V. Martin's ideas for a retractable undercarriage.

The Blériot-Spad outfit also went ahead in 1924. The Spad single-seat fighter with a 300 h.p. Suiza engine was doing 155 m.p.h. and another Spad which had a Jupiter engine of 420 h.p., built by the Gnôme-Rhône people under license to the Bristol Co., was doing 164 m.p.h. A truly remarkable performance.

Dewoitine was coming along nicely and was getting 153 m.p.h. out of a high-winged monoplane with a 300 h.p. Suiza and something more, unspecified, out of a similar machine with a 420 h.p. Jupiter. This machine was remarkable because it had two machine guns mounted on top of the high wing, outside the radius of the air-screw. That was one step towards the outside gun.

Nobody else in France produced anything noteworthy.

In Germany Udet continued to get startling performances out of low powers. But there was nothing which could yet be called

a fighter. In Holland neither Koolhoven nor Fokker produced anything new.

In Italy, Piaggio of Genoa turned out a very smart looking single-seat low-winged monoplane, which with a 300 h.p. Hispano-Suiza engine did 160 m.p.h. It carried two synchronized machine guns and today it looks extremely modern. And the Fiat CR single-seat with a 300 h.p. Suiza was doing 165 m.p.h. Speeds were definitely going up. That Fiat speed was not bad for a biplane.

In the United States we now come across the name of the Boeing Airplane Co. of Seattle. The President then was Mr. G. M. Gott and the Chief Engineer and Secretary was Mr. C. L. Egtvedt, who is still the moving spirit on the technical side. The firm, which in 1921 had built ground attack machines with two Liberty engines, in 1923 built some modifications of the Thomas-Morse fighters. But not until 1924 did they come out with the real Boeing pursuit plane, a biplane which had an upper plane much bigger than the lower plane both in span and chord. With a Curtiss D-12 motor of 400 h.p. it did 165 m.p.h.

From then began the rivalry with the Curtiss Co. for the first place among American fighters.

Also in 1924 we come across for the first time the famous Curtiss Hawk, officially known as the PW-8A. An interesting point about this machine was that although the upper wing had a bigger span than the lower, the upper and lower wings right and left respectively were interchangeable. The bigger span of the upper plane was caused by the width of the centre section. That was very practical from the point of view of supply of spares in the field. The excellent outline of the fuselage was rather spoiled, as in the Boeing, by a big radiator carried in a metal-cased tunnel right under the back end of the motor so that it hung down in front of the undercarriage. In spite of this, with the Curtiss D-12 motor, now rated at 420 h.p. it had a top speed of 158 m.p.h. and a landing speed of 65 m.p.h. It climbed to 12,000 feet in 10 minutes and, in spite of not having a supercharger, it had a ceiling of 23,400 feet.

About these Curtiss Hawks there is a story which is well worth careful study today. The chiefs of the U. S. Army Air

Service (not yet the Air Corps) wisely reasoned that there was no use in having very high speed single-seat fighters which, to get a high performance, could only carry enough gasoline for a patrol of 2½ to 3 hours. They argued that, although nobody talked about war with Japan, there was always the possibility that squadrons on the Atlantic side might have to fly across the Continent in a blazing hurry to meet a Japanese attack, even though it might be only bombers and not a full dress invasion. So they asked the Curtiss Co. what about it?

The Curtiss Co.'s answer was to fix a petrol tank under the belly of the machine, behind the undercarriage, which fitted flush to the belly, and came down behind the radiator tunnel, and then streamlined up gracefully to the tail. To the astonishment of most of the people concerned, though perhaps not of the Curtiss designers, the Hawks with the tanks on were five miles an hour faster than those without the tanks. These extra tanks enabled the Curtiss Hawk to cross the Continent, with three stops for refueling, and gave it a range of 1,000 miles.

In this experience there is a moral to be learned by designers of modern fighters. The British Army suffered badly in Norway, in Greece and in Crete because we had no fighters which were able to reach those countries from such bases as we had, in Scotland opposite Norway and in Egypt opposite Greece, and carry enough gasoline to get back after fighting.

With supplementary tanks of this sort fitted to Hurricanes and Spitfires there is a possibility that the fighters might have been able to reach Norway or Greece or Crete with their normal gasoline tanks full, and then, by some simple device, they could have cut loose their empty tanks and have done at least an hour's fighting, and still have had enough gas left in their tanks to get them home again. But in their normal state they could not carry enough gas to get there and back and fight.

In 1924 the Curtiss Falcon was a very good two-seat fighter-reconnaissance biplane. This had a 400 h.p. Liberty engine or a 500 h.p. Packard or a 400 D-12. The official number of the machine was the X.O.I. It carried one Browning machine gun in front (rifle calibre) and two Lewis guns aft. With a Liberty its speed was 152 m.p.h. and with a Packard it was 158.

In 1924 also we come across the Chance Vought Corporation, Long Island City. A firm called Lewis & Vought had existed but had not done much. But Vought, on his own, specialized on making airplanes for the Navy, and managed to get 122 m.p.h. out of a biplane with a 200 h.p. Wright radial motor, which was very good.

The Wright Aeronautical Corporation continued to increase speeds with their 450 h.p. Wright T.M.V. motor. Their Pulitzer Trophy Racer F-2W had a high speed of 240 m.p.h. and a low speed of 55 which was remarkable.

Much of the improvement in the performance of American airplanes at this time was caused by the use of solid duralumin air-screws, which for high-speed work practically took the place of wooden built-up air-screws.

THE ENGLISH REVOLUTION

In 1925 British aviation was startled by the appearance of two remarkable airplanes, the Fairey Fox and the Fairey Firefly. Mr. C. R. Fairey had visited America early in 1924, after the smashing victory of the Curtiss Racers in the Schneider Trophy contest at Cowes, Isle of Wight, in 1923, and he bought licenses to build two Curtiss designs. The results were these two machines. The Fox was a two-seat fighter-reconnaissance biplane and the Firefly was a single-seater. Both had the Curtiss D-12 motor, now pushed up to 430 h.p.

The Fairey Fox was one of the most popular airplanes the R.A.F. has ever had. Its pilots loved it, and it was beautiful to behold. Also, at flying meetings, especially at the great R.A.F. Display at Hendon, when 200,000 people gathered to see the R.A.F. show off, the scream of a squadron of diving Foxes was one of the thrills of the day.

Mr. Fairey's original intention was to build the D-12 motor in this country and call it the Fairey Felix. He imported a number of D-12's, enough to equip some squadrons of Foxes and Fireflies, and to leave a few over for spare.

Here another bit of history may be related. We, in England, had done very well with the Rolls-Royce twelve-cyclinder Falcon motors in Bristol Fighters and the Rolls-Royce Eagle in

bigger machines. The Eagle at this time was giving 360 h.p. and the Falcon 270 h.p. They had separate cylinders with copper water-jackets.

The Curtiss D-12 was the first engine in the 400 h.p. class which had its cylinders cast in a block, like car engines. It did so extraordinarily well in the Faireys that more people began to think about it. So Lieutenant Colonel Rudston Fell, then in charge of aero-engines at the Air Ministry, showed the D-12 to the Rolls-Royce people and asked them to go and beat it. The result, after due time for design and experiment, and type-testing and improvement, was the Rolls-Royce Kestrel, admittedly one of the finest aero-motors ever built.

This was followed by the Merlin, so that the Kestrel and the Merlin took the place of the old Falcon and Eagle. Today the Merlin is giving something well up towards 2,000 h.p. and a new engine which is based on the Merlin and is called the Vulture, is away in the direction of 2,500 h.p.

Thus one sees that Mr. Fairey's little private gamble in buying Curtiss motors and Curtiss designs for airplanes set an entirely new fashion in this country. And I am not saying too much when I state that the results of following those basic ideas have been the remarkable series of English fighting airplanes which have, although it may seem premature to say so, won this war.

I claim that I am right in that statement because, if our Air Force had not been so well mounted, and had not been able to trust its engines and its airplanes as our fighter pilots did, we should have lost far more men in the retreat from Dunkirk, and we should probably have lost those colossal air battles over the English Channel and over the Straits of Dover in September, 1940, which proved to the Germans that any attempt to invade this country by air in daylight must fail.

If at that time, September, 1940, the Germans had owned any more fighters they would have pushed them into the battle and if they had owned any more big bombers they would have used them to smash up our industrial districts while our fighters were so busy on the other side of the Channel.

But they did neither so we may assume that they had not the men nor the material to defeat us in the air at that time, in spite

of their much advertised superiority in numbers. Although in fact our fighters were facing the Germans in the proportion of one of our men to five Germans the German losses were colossal compared with ours.

Since that time, although the German output of fighters and bombers may have increased it cannot possibly have increased to the same extent as ours. Consequently our strength in the air today in proportion to the Germans is far higher than it was in the summer and autumn of 1940.

The superiority of our people is in mental activity, moral status, and the sporting fighting spirit. The Germans are tough fighters as any of our fighting men will admit. But as they could not beat us then they are not likely to beat us in the future when the balance of man power and machine power is in our favour. Thanks largely to American help in material, and to the help of the British Dominions in man power, we are daily growing stronger and stronger in comparison with the Germans.

HIGH SPEED IN 1925-26

Various firms made interesting airplanes during 1925 but to deal with them individually would make this treatise far too long. So I must skip everything except those machines which contributed definitely to the development of today's combat airplanes.

One such quite definitely was the Hawker Hornbill. It was a high performance single-seat fighter biplane in which was fitted a 700 h.p. Rolls-Royce Condor. It was built in 1925 and at that date no performance figures were allowed, but the machine is interesting because when the Kestrel engine came through, although it did not give 700 h.p., it was so much smaller and lighter and so much more reliable than the Rolls-Royce Condor that the Hawker Co. in 1928 built a variation of the Hornbill with a Kestrel motor which was called the Hornet. That later became the Hawker Fury, one of the best single-seat biplane fighters ever made. For two or three years there was bitter rivalry between it and the Fairey Firefly. Everyone wanted to see the two compete in public, but only the R.A.F. Experimental Establishment at Martlesham Heath knew their exact perform-

ance figures. The Fury was ordered by the R.A.F. as the standard liquid cooled combat airplane.

When the Hawker Co. decided to build a monoplane fighter it was called the Fury Monoplane at first. Then it became the Hurricane. These changes will be discussed in detail later.

Another history-making machine of 1925 was the Supermarine Napier S-4 float-plane biplane which was designed and built as part of the Air Ministry's program of high-speed development and was loaned back to the builders, the Supermarine Co., for entry in the 1925 Schneider Trophy Contest. It had a speed of 239 m.p.h. with a 700 h.p. Napier Lion engine, in spite of its pontoon floats. This was the airplane from which the present day Spitfire fighter is directly descended.

A French airplane which must be mentioned, chiefly because of its long continued use, and because in a way it introduced some new features was the Breguet XIX.B.2. It was a biplane with a very big upper plane and a much smaller lower plane which were connected by an I-shaped single strut on each side of the fuselage. The whole fuselage was cased in aluminum made up of strips drawn into a channel shape and then riveted together by their flanges. The undercarriage was a queer affair consisting of two straight legs which raked far forward. Between them was a cross-axle. The only spring in the undercarriage was in the wheels themselves. The lower plane was braced by the lower end of the I-struts to the hubs of the wheels, and the I-struts were tension members to take the lift of the upper plane when flying and compression struts to take its weight when landing.

In spite of the abolition of all cross-bracing except two landing wires from the top of the fuselage to the bottom of the I-strut, and although the machine looked an excellent streamline shape, its speed was only about 135 m.p.h. with a 440 h.p radial motor.

It carried three machine guns forward, two Lewis guns on a Scarff ring aft, and one Lewis pointing down under the tail. In various forms the Breguet XIX lasted almost until the outbreak of the present war. And it was the only French two-seat fighter worth talking about.

A constructor who began to be talked about at this time was M. Michel Wibault. As a young man during the War 1914-18 Wibault had been caught in Lille by the German occupation. There he experimented quietly with models of aircraft in a small wind tunnel which he built in an attic. During 1922-23, being a cripple, he was allowed to go into unoccupied France by way of Switzerland. And there, directly after the war, he managed to get financial backing to continue his experimental machines. By 1925 he had produced the Wibault VII B.1. which with a Jupiter engine of 380 h.p. had a speed of 137 m.p.h. which was not alarming, but it had a ceiling of 30,000 feet which in unsupercharged days was remarkable.

Another of his machines with a 450 h.p. Suiza had a speed of 143 m.p.h. and a ceiling of nearly 25,000 feet which made it quite a useful fighter.

By 1925 we began to hear a good deal in Germany of Dr. Claude Dornier. He had built some very good airplanes during the war, and was now experimenting with small flying boats.

Another name which we heard for the first time about 1925 was Focke-Wulf. At that time Dr. Focke (not to be confused with Anthony Fokker) was still making small machines.

Dr. Ernst Heinkel was already starting to make planes again at Warnemunde on the Baltic. And his seaplanes, with as much as 360 h.p., were being built in Stockholm as he was not allowed to build them in Germany.

Dr. Junkers, more fortunate, had managed to win the approval of the Inter-Allied Commission to build tri-motor civil aircraft for transport lines. These were the direct parents rather than the ancestors of the familiar Ju-52 which before this war was one of the most popular passenger machines in the world, and since this war began has become notorious as a carrier of troops and of parachute-troops, and as a tower of gliders.

Here we may spare a few lines to say that in 1925 Ernst Udet produced a four-engine cantilever monoplane called the Condor which carried four Siemens air cooled radial engines of 100 h.p. each in a species of cradle underneath the wings

and drove pusher air-screws through shafts behind the trailing edge. It was particularly interesting and it was surprising because Udet, a fighter pilot, always favoured small single-seaters.

In the United States 1925 was another year of triumphs for the Curtiss Airplane and Motor Co. Lieutenant Cyrus Bettis of the U. S. Army won the Pulitzer Trophy Race in New York with a speed of 248.98 m.p.h. over a 200 km. course. Two weeks later the same machine, fitted with pontoon floats and flown by Lieutenant J. H. (Jimmy) Doolittle of the U. S. Army, won the Schneider Trophy with the remarkable average of 232.57 m.p.h. Next day, the same pilot, put up the world's record for seaplanes to 245.71 m.p.h.

These racers are always worth noting because the record speed of today becomes the normal top speed of to-morrow, and the lessons learned in building and testing racing machines can always be applied to the improvement of fighters.

A definite hook-up was arranged about this time between the Curtiss Co. and Mr. S. A. Reed, and the Curtiss-Reed metal air-screw was put on the market.

In 1926, or thereabouts, the Jupiter VII supercharged engine came into service with the R.A.F. It is the first mention we have of supercharging. And for that year at any rate, the performance figures of the Bristol Bulldog were kept a deadly secret—"Known to everybody but ourselves", as a wag said.

The influence of the Curtiss-cum-Fairey "Eversharp" style became evident again in 1926 with the Series III Fairey biplanes. They looked much like enlarged Fairey Foxes. The Fairey III F. Napier Lion, (twelve-cylinder Broad-Arrow-type engine of 450 h.p.) was a two-seat fighter which had a speed of 126 m.p.h. but a touring speed of 86 m.p.h. which gave an endurance of 5½ hours, and a range of 465 miles; which was remarkable in these days. The performance figures of the Fox and the Firefly were still kept a deadly secret.

In 1926 we were allowed to know the performance figures of the Hawker Hornbill, which, as I have said, is the direct ancestor of the Hurricane. With a 700 h.p. Rolls-Royce Condor, direct-drive, it did 184 m.p.h. So you see how we were even then creeping up to fairly high speeds.

At the Supermarine Co. R. J. Mitchell was going ahead with the building of his Schneider racers from which the Spitfire has descended. The Supermarine Napier S-4 which was produced in 1925 had in September of that year set up a world's speed record of 226.8 m.p.h. and by 1926 the speed had been pushed up to 239 m.p.h., mostly by improving the exterior of the machine.

In 1926 we hear of Herr Willy Messerschmitt for the first time. He had already made a name for himself by designing highly efficient gliders, or rather sailplanes, which had done well in competitions. His first airplanes looked rather as if he had put engines into ordinary sailplanes. But they had remarkable performances. One which had a 32 h.p. Bristol Cherub motor carried two people and did 84 m.p.h. The other, which was a little cabin monoplane had a top speed of 87 m.p.h. with a 100 h.p. Siemens motor, and carried four passengers and pilot, and it was built of steel and duralumin. So he was already making for efficiency.

In Italy the Fiat Co. had already reached the CR-20 and had so improved it with 400 h.p. Fiat motor that it did 168 m.p.h. and was climbing to 7,000 ft. in 17½ mins. The CR by this time had begun to look very much as the modern machines do. Instead of the wing cellule being of stick and string, as we used to say, it had steel tube struts arranged like a Warren girder to take compression and tension. These were arranged in Vee's without any wire other than the fore-and-aft bracing.

The Macchi firm which had long been building successful biplanes, during 1925-26 built a series of single-seat racing monoplanes fitted with a special 800 h.p. Fiat engine. One of these machines had won the Schneider Contest at Norfolk, Virginia, in 1926, more or less by an accident which put other competitors out, and that was why the 1927 Contest was held in Venice.

The winning Macchi some weeks later in 1926 flown by Major Mario de Bernardi raised the world's speed record for seaplanes over a 3 km. course to 416 km. p.h. I believe this was the first time that 250 m.p.h. (416 km. p.h.) had been beaten. The same machine and pilot averaged 399 km. p.h. over a 100 km. course.

STILL RISING SPEEDS IN 1927

The British contribution to aviation in 1927 was the Supermarine S-5 float-plane, with the 1,000 h.p. Napier Lion engine. In one of them Flight Lieutenant Webster won the Schneider Trophy at Venice in September at 281.65 m.p.h. Flight Lieutentant Worsley, who was second did 273 m.p.h. The winner's speed beat the existing landplane record by 3 m.p.h. Early in 1928 Flight Lieutenant Darcy-Grieg raised the speed record in one of them to 319.5 m.p.h. over the 3 km. course.

The Curtiss Hawk Biplane remained as before the star turn fighter of the United States. But in 1928 the Curtiss Co. fitted one of their new 700 Curtiss V-1550 motors, known as the Conqueror, to a standard Hawk and this machine put up an average speed of 189 m.p.h. while competing in an air race at Spokane. At the same meeting Lieutenant A. Batten, A.C., in the same machine put up a speed of 201 m.p.h. in a free-for-all race for pursuit ships.

Here, for history's sake we should record the names of those who made the Curtiss Co.'s great successes. Glenn Curtiss, the founder, had retired. The President was C. M. Keys, the Vice-Presidents were Frank Russell (one of the 1908 pioneers), Leonard Kennedy and Roy Keys. The Chief Engineer (Aircraft) was T. P. (Ted) Wright and the Chief Engineer (Engines) was Arthur Nutt. Both of these distinguished engineers were still at work in 1941.

The curious thing is that although the Curtiss single-seaters, which were definite steps in the evolution of combat airplanes, did so well, the type was never developed further. Although the Conqueror engine gave a good 600 h.p. it was never produced in large quantities. And, so far as I know, the Curtiss Co. eventually gave up building the Conqueror.

Possibly this was because the prevailing trend in the United States was towards air cooled motors. The Wright Co. and the Pratt & Whitney Co. progressed so far with their air cooled radials that on weight for power they left the water cooled engines behind. The old solid Liberty, which did such grand work in its time, was never a power plant for a pursuit ship. And, it was in a way an orphan product for no one firm was its

father or mother and so nobody was interested in developing it and refining it.

The Packard people apparently lost interest in air affairs. Although they made a gallant effort to develop a Diesel motor, also an air cooled radial, which had very daring and original designs in it, probably the temptation to make big money out of automobiles to an unlimited extent, compared with the precarious profits to be made out of Government orders for aircraft and aero-motors, turned the balance against aircraft.

In 1927 aviation folk heard for the first time of a firm whose name has become famous in this war. That was the Lockheed Aircraft Co. The President was Fred Keeler. The Vice-President was Alan Lockheed, a younger brother of Victor Loughead, who spells his name differently and is notable as an inventor. The Chief Engineer was P. F. Hunter. The Secretary was John K. Northrop, whose name is also world famous as a maker and designer of high-speed craft. The Lockheed people did not at this time make combat airplanes. Their great success was the Lockheed Vega which, with a Wright Whirlwind of only 220 h.p., had a speed of 135 m.p.h. and carried a pilot in an open cockpit and four or six passengers in an enclosed cabin. A somewhat similar machine built as an air mail express with a Pratt & Whitney Wasp engine of 425 h.p. had a top speed of 170 m.p.h.

From these descended the Lockheed bomber-reconnaissance-fighter plane which has done so marvellously in the Coastal Command of the R.A.F., and the Lockheed Lightning, of which at the time of writing we have seen nothing in England. Nevertheless, knowing something of the Lockheed Co., I am ready to believe that it is one of the world's finest and fastest fighters.

The Wright Aeronautical Corporation, the President of which was Mr. Charles Lawrance, the pioneer of radial aero-motors in the States, practically dropped making airplanes in 1927, and turned all their attention to making motors. Mr. Guy Vaughan, who was Vice-President and General Manager in 1927-28, remained head of the firm and pulled it through the bad slump at the end of 1930.

Another interesting point to note in 1927 is that the Allison Engineering Co., which suddenly became world famous in 1941 because they produced a liquid-cooled twelve-cylinder motor of 1,100 h.p., were already doing general aero-engine development. In 1927 it took over the interesting job of making inverted Vee air-cooled versions of the good old Liberty, both as a direct-drive and a geared engine. If my memory serves me right Mr. Herring, who was working at the newly-organized Wright Field, the experimental station of the U. S. Army Air Service, at Dayton, Ohio, was already experimenting with an inverted air cooled version of the Liberty in 1924.

For some reason that line of development was not followed to a logical conclusion and the first high-powered multi-cylinder in-line air cooled motors were the Napier Daggers, consisting of four banks of six cylinders, designed by Major Halford, in this country.

By 1927 the Pratt & Whitney aero-engine had become quite famous. This company, which was a subsidiary of the world-famous tool-making company, was formed in 1925. The President was Mr. Fred B. Rentschler. The Vice-President and Technical Adviser was Mr. George J. Mead, who went to Pratt & Whitney from the Wright Corporation.

These historical facts about the makers of aero-motors are worth recording because they have so much to do with the later development of combat airplanes. The great argument among technical people is whether any possible form of air cooled aero-motor can give the performance of liquid cooled motors. I hope to say something on this subject later on. One could easily write a whole treatise on the arguments for and against these types.

NEW STEPS IN 1928

There was no remarkable progress in combat airplanes in the United States in 1928. American planes had ceased to compete in the Schneider Trophy Contests, which were the only incentive left for the builders of high-speed single-seaters. Nevertheless the Curtiss XP-60 of 1928-29, with a 625 h.p. Curtiss Conqueror water cooled motor, had a speed of 182 m.p.h. Which after all was not so much better than the 165

m.p.h. of the standard U. S. Army Air Service Hawk, the P 11-6 with a Curtiss D-12 engine, which had now stepped up to 435 h.p.

Practically all the energy and intelligence of the U. S. designers at this period were concentrated on making more and more efficient civil air transport machines. Chance Vought was still making fighters for the Navy which put up quite a good performance but they did not mark any direct steps in evolution.

The first firm in England to produce a high-speed monoplane fighter was the De Havilland Co. which turned out the DH-77, with a 300 h.p. Napier Rapier engine. Its top speed was 203 m.p.h. with 300 h.p. whereas the strut-and-wire biplanes of various nations were doing about 150 to 180 m.p.h. with engines of anything from 400 to 600 h.p.

The Napier engine in this machine had four banks of four air cooled cylinders. In fact it was two eight-cylinder double-opposed engines placed on edge. Two sets of cylinders were upright side-by-side and two sets of cylinders were upside down side-by-side, the up-and-down cylinders drove one crank-shaft on each side and the two crank-shafts were geared to a central air-screw shaft.

From the Napier Rapier was developed the Napier Dagger which has been doing well in some of our Handley Page bombers, and from that has been developed the Napier Sabre which, in the middle of 1941 at any rate, was the most powerful engine in the world which was flying regularly. Lord Beaverbrook announced that it was giving some 2,300 h.p.

For reasons known to the High Authorities the DH-77 was never developed farther.

STILL THE SPEEDS RISE

In 1929 the Fairey Firefly and Fox were both modified to take the 480 h.p. Rolls-Royce F.XII, which later became known as the Rolls-Royce Kestrel. Still no figures of performance were available.

The Gloster Co. under Mr. H. P. Folland, built a couple of good racing machines in this country but had some obscure trouble with the air intake of the motors—with the result that

although one of them put up a world's speed record of 336.3 m.p.h. on September 12, 1929, they did not compete in the contest. The contest was won by the Supermarine S-6 flown by Flight Lieutenant H. R. D. Waghorn, which did 328.86 m.p.h. over the course. Later on Wing-Commander Orlebar put up a world's speed record of 357.7 m.p.h. in one of these machines.

THE HAWKER EVOLUTION

From 1930 onwards the Hawker Fury with the Rolls-Royce Kestrel motor was the standard fighter of the R.A.F. With the 480-490 h.p. Rolls-Royce twelve-cylinder Vee-type water cooled Kestrel engine its speed was 207 m.p.h. at 10,000 feet and 214 m.p.h. at 13,000 feet which was its best height. Those are the official figures of the production type machine and not the test figures of a prototype.

At the same time the Hawker Hart became the standard two-seat fighter of the R.A.F. It had the same Kestrel engine, carried two synchronized guns forward and two guns in a ring aft. Its top speed was 184 m.p.h. and it climbed with full war-load to 10,000 feet in 8 minutes.

From the Hart a variety of types were evolved. The Demon was practically the same thing but the aft gunner was sunk lower in the fuselage and the guns were arranged so that he had a better field of fire.

As the Hart was developed as a fighter various types of cowling were put over the back seat to protect the gunner from the wind; because as speeds went up the gunners found more and more difficulty in holding their guns at any considerable angle from a straight line aft because of the air pressure on the sides of the projecting barrels.

Although a gunner might be able to manipulate his guns all right when the machine was flying level or gliding gently he found great difficulty in doing so when the machine was diving at something over 250 m.p.h. And this scheme for a more powerful control over the guns led to the production of the mechanically driven gun turret on which more appears later.

An interesting example of foresight which failed was the French Villiers V-24 biplane, which was a high-wing mono-

plane with very small lower planes. This was designed specifically as a night fighter. So far as I can discover it was the first attempt to build a machine deliberately for that purpose, except a peculiar affair which was built by Mr. Pemberton Billing during the War of 1914-18. That machine never came into action, which was why I did not mention it while discussing the war-time fighters.

This Villiers machine had a 450 h.p. Lorraine water cooled engine of the W type, that is to say two banks of Vee cylinders with a bank of vertical cylinders in the middle. The upper planes had Handley Page slots all along the leading edge and an enormous slotted flap along the trailing edge. The outer sections of this acted as ailerons.

Its top speed at ground level was 131 m.p.h. and the minimum speed with the slots open was 46 m.p.h., which was obviously the right thing for night landing. Unfortunately the firm only endured for a few years and nobody else took the trouble to develop a properly slotted and flapped airplane for night fighting.

Germany by this time (1930) had broken away from the Versailles Treaty obligations to the extent of making big engines, but they had not yet dared to come out in the open and build fighting machines, or obvious bombers. Some of the performances which were being got from so-called "civil" airplanes showed what could be expected in the future.

In the United States both the Army and the Navy began to think about serious arming. Japan was beginning to look awkward. One of the largest contracts yet given to a manufacturer was that to the Boeing Co. for a number of P-12-BC's. This was a very useful biplane with a 450 h.p. engine. The speed was 171 m.p.h. and it climbed to 3,500 feet in 10 minutes. The Navy also ordered a number of the F-4B1X.

THE HELLDIVERS

The Curtiss Co. stuck to their single-seat combat machines, but the product which caught the public fancy for 1929-30 was the famous Helldiver. Officially it was the FC-4 two-seat fighter and light bomber with a 450 h.p. D-12 motor. Its specialty was diving vertically at full power when bombing.

Who thought first of vertical dive bombing is as much a mystery as is who first thought of building eight-gun fighters with all the guns outside the air-screw. But the fact is significant that the U. S. Navy was the first Service to order vertical dive bombers.

The reason that the Navy needed such ships is fairly obvious. No matter how clever may be the instruments which are evolved for what is professionally known as "precision bombing", an airplane flying horizontally at fairly high speed is never quite so likely to hit the deck of a ship from say 10,000 feet, which is dangerously low, as is a dive-bomber going straight for its target regardless of consequences and releasing its bombs when only perhaps a hundred or two feet from the deck. Moreover the most highly developed bomb sight needs quite a lot of calculation and manipulation, whereas all the dive bomber has to do is dive at his target watching through his ordinary gun sight.

Compared with precision bombing, dive bombing needs comparatively little intelligence, but, on the other hand, the dangers are so much greater that it needs even greater courage, or recklessness, or fanaticism, whichever may be the moving power behind the mind of an aviator in wartime.

There is no question that the Curtiss Helldiver built for and under the supervision of the U. S. Navy was the one and original dive bomber.

For the sake of our insular pride and prestige one may perhaps hope that the idea of the Helldiver was conceived as the result of viewing the converging bombing at the R.A.F. Display at Hendon by a squadron of the Fleet Air Arm in Fairey Flycatchers, which, as I think I have mentioned, were reputed to be the only airplane which ham-handed sailor men could not pull to pieces in the air. I imagine that the Curtiss Helldiver was built on somewhat similar principles.

CLEANING UP

You will notice that we have now reviewed the air history of ten years since the last war, and yet nobody had taken to retractable undercarriages. The Lockheed people alone had got as far as putting spats on their wheels, by way of doing some-

thing to decrease the obviously awful obstruction set up by pushing that most unstreamlined shape, an ordinary wheel and tire with accompanying struts and stays, through the air.

Another startling thing about the design of that period is that everybody left the cylinder heads of their radial engines sticking out in the air and causing a most obvious obstruction.

Somewhere about that period the late Anthony Fokker, talking to me about airplane designs, remarked that a boat designer had the advantage that he could *see the spray* and so could see whether his boat was "clean" or not. "And", said he, "if we could see the spray in the air most airplane designers would be ashamed of themselves". He added, "Can you imagine a boat designer who wanted to get more power sticking extra engines outside his boat on a pontoon or a kind of catamaran on each side. And yet we go and stick our engines out in the air on the wings."

Also much about this same period the most brilliant of British aero-motor designers, who had visions of engines which did not stick out in the air, told me that he had got out the general design for a twelve-cylinder double-opposed flat (horizontal) air cooled motor of 800 to 1,000 h.p. He showed them to a number of prominent airplane designers and not one of them was interested.

Today we have come somewhere near that kind of design in the Napier Dagger twenty-four-cylinder engine which consists of two flat-twelves. Obviously if they can run with two sets of cylinders up and two sets of cylinders down, they can run equally well with all four sets of cylinders horizontal.

Another step towards the fighting airplane of today was the Gloster SS-9 biplane which had a 480 h.p. Bristol Jupiter VII F. It had four Lewis guns mounted in the wings, two on each side, and firing outside the air-screw radius. It carried 1,600 rounds of ammunition per gun. Which with a firing rate, in those days, of about 800 rounds per minute meant two minutes' firing.

The speed of the machine at ground level was 170 m.p.h. and it landed at 57 m.p.h. The engine, which was supercharged, gave 450 h.p. at sea level and 530 h.p. at 8,000 feet. This I

believe was the first multi-gun fighter which fired all its guns outside the air-screw, *and* had a supercharged motor.

THE SCHNEIDER TROPHY AND WORLD'S RECORDS

The greatest triumph in British aviation in 1931 was the winning outright of the Schneider Trophy. Flight Lieutenant J. N. Boothman, R.A.F., flew over the course, for lack of other competitors, at a speed of 340.08 m.p.h. in a Supermarine S-6B with a Rolls-Royce R engine. The same day Flight Lieutenant G. H. Stainforth, R.A.F., put up the World's Speed Record with a similar machine to 379.058 m.p.h. And on September 29, 1931, in the machine in which Flight Lieutenant Boothman had won the Schneider Trophy, but fitted with a special engine which gave 2,600 h.p., he raised the world's speed record to 407.5 m.p.h. That was the first time that 400 m.p.h. had been beaten.

I may remark here that Lady (Lucy) Houston, who had financed the first flight over Mount Everest a year or so earlier, put up £100,000 to pay for our Schneider team because, like the U. S. Navy, the Air Council was no longer interested in or amused by the contests.

Naturally these Rolls-Royce R engines were in a way fakes. They were designed for particularly high compression and were lightened in all sorts of ways, so that they could not be expected to stand up to regular combat work. They used a special fuel in which I believe there was very little petrol and a lot of alcohol, and tetra-ethyl lead. But they did what they were wanted to do while they were wanted to do it. And if one considers them as fighters which, in spite of having to drag enormous floats and struts and wires through the air, reached a speed ten years ago which would be considered quite good for a fighter today, one sees that the evolution of the combat airplane was progressing.

THE RETRACTABLE UNDERCART

The first recorded example of the retractable undercarriage is that in the Boeing Monomail, a high-performance mail carrier of 1930-31, fitted with a 575 h.p. Pratt & Whitney Hornet engine. It had a top speed of 158 m.p.h. which, considering

that it weighed 4,610 lbs. empty and 8,000 lbs. fully loaded, showed the great advantage of having a retractable undercarriage.

I think that Mr. Boeing, or rather Mr. Egtvedt was ahead of all his competitors that year, because I can find no other airplane in the States, and naturally, none in Europe, which tucked up its wheels. The most that anybody got to, even John Northrop, were elaborate spats or pants over the wheels.

In 1932 we come across another retractable undercarriage, the Grumman XFF-1, a single-bay biplane two-seater with a 600 h.p. Wright Cyclone engine, which was fitted with the Townend low-drag cowling ring.

Here is a curious example of the processes of evolution. The retractable undercarriage, the shape of the fuselage, and the low-drag cowling, had all the makings of a real high-speed airplane. And yet all that went into a biplane with steel struts and wire bracing whose general aspect might have belonged to 1918. Just why nobody thought of making a fuselage of that sort into a middle-wing monoplane is inexplicable.

In 1933 we meet the first retractable undercarriage in a British airplane, namely the Airspeed Courier, primarily a single-engine six-seat low-wing civil airplane. But from it was developed the twin-engine Oxford now used as Air Force trainers. And at any rate Air-Speed Ltd., deserves credit for being the first firm to pull up their wheels.

During this long barren period of the early 1930's, the French kept on producing all kinds of ingenious airplanes, on which one might well discourse if one were merely writing the history of stunt designs in general, and especially if one were writing a comic treatise. But the unhappy fact remained that right up to the outbreak of war in 1939 the French never produced a single airplane which in any category, big or little, marked any notable advance over the best existing airplanes in other countries. In fact the output of the French aircraft industry for this ten years was a monument of misplaced ingenuity.

In 1933 the German designers began to show up. As I have already said they had cut loose from the Treaty of Versailles

to the extent of building big engines and big airliners. And they put those engines into civil airplanes which had remarkable performances.

Dr. Heinkel produced the He-70A, a seven-seat express monoplane with a 700 h.p. B.M.W. VI. engine which had a top speed of 234 m.p.h. and climbed to 6,500 feet in 7 minutes, and carried gas for 620 miles range.

The Junkers 52 tri-motor monoplane, which was to become notorious in this war, and was a standard passenger carrier for years before, showed up in 1932. Strictly speaking it is not a combat airplane but it does seem to be worth mentioning. This machine with a German-built (B.M.W.) Hornet of a Pratt & Whitney design, had a top speed of 128 m.p.h., a cruising speed of 112 m.p.h., a range and cruising speed of 1,240 miles, and passenger accommodation for 14 to 17 passengers.

Herr Messerschmitt had by this time got as far as building mail planes with two 525 h.p. Hornets, which had a top speed of 158 m.p.h. But he was not then building high-speed types.

Italy again comes into the picture in 1933 with the Macchi-Castoldi racing seaplane which had a 2,500 h.p. Fiat engine. This consisted of two Fiat Vee-type twelve-cylinder engines in line, one driving its air-screw shaft through the camshaft of the other but in the opposite direction. Thus the two air-screws close together ran in opposite directions, and completely removed the bugbear of torque.

This machine put up a world's speed record in April 1933 of 423.7 m.p.h.

THE SMALLER NATIONS

About this time 1932-35, various nations made praiseworthy efforts to produce combat airplanes of their own, but few of them showed any originality. Most of them were what are called "Chinese copies" of either British, French or American airplanes.

The Poles did show some originality by building quite a number of interesting high-wing monoplanes, with very tapered wings of curious sections. Some were like the British Army Cooperation Lysander, or perhaps I should say that the Lysander is like them, as they were five or six years earlier.

The Japanese tried to display originality by taking a bit of one airplane and a bit of another and putting them together so that nobody could say that the machine was a direct copy of anything, and yet it looked like a lot of other people's work.

Some other quite small nations, for instance the Czechs, the Netherlanders and the Rumanians did introduce definitely novel airplanes. But none of them had a performance which would justify discussing them at length in this work.

AN EPIDEMIC OF ORIGINALITY

America had an epidemic of interesting types in 1932-33-34. Mr. Gerald Vultee, commonly called Jerry, of the Airplane Development Corporation produced an eight-passenger monoplane which was quite definitely the forerunner of the fast Vultees of a later date.

Colonel Virginius Clark, who had been one of the chief technical officers of the U. S. Army Air Service in 1918, and Major Temple N. Joyce, a war-time pilot, formed the B-J Aircraft Corporation Ltd., as a branch of the General Aviation Corporation, and produced a very fine two-seat fighter biplane, with a 600 h.p. Curtiss Conqueror.

This, incidentally, is the first time one comes across the mention of Prestone cooling. In these days practically every liquid cooled engine uses Glycol as a cooling fluid, more commonly called a "coolant", and the expression "water cooled", although used conversationally, is technically inaccurate. Colonel Clark, of the famous "Clark Y" wing section, later introduced the Duramold system of making fuselages in moulds out of plastic materials.

In 1933 Boeing produced the famous P-26A single-seat fighter monoplane with a 525 h.p. Whitney Wasp engine. This machine was said unofficially to have a top speed of 231 m.p.h.

Three or four years later copies of it built in Russia became famous, or notorious, in Spain as the Rata, or Rat, the fastest fighter flown by the Red Air Force, and, generally flown by Russian pilots.

The machine had an elaborately streamlined undercarriage, thin wings which were braced on top to the fuselage in which

the pilot was perched very high up, and all the flying loads were taken by wires from below the wings to the undercarriage. Thus a lucky anti-aircraft shot or a stream of bullets from an enemy fighter which happened to cut away the junction with the undercarriage left the wings to fold up.

It was much faster than the little Italian CR-42 Fiat fighters in Spain but nothing like so manoeuvrable, and when the Fiats climbed above it they could always catch it by diving on it.

Reuben Fleet's outfit, the Consolidated Aircraft Corporation, built in 1932 a small fighter but only with a 150 h.p. Kinner engine. It was built for the Navy to hook on underneath airships. The pity is that the U. S. Navy ever gave up airships with attached fighters. They would have been most valuable today scouting for enemy submarines; and surface raiders could have been located anywhere within a radius of 50 miles or so of the airship by its airplane scouts.

Actually the first drop-off and hook-on to an airship was done on October 15, 1925, by Squadron Leader R. A. de Haga Haig, R.A.F., from and onto H. M. Airship R33.

The Curtiss Co. also made a biplane with a 428 h.p. Wright Whirlwind called the Sparrow Hawk which was likewise designed to be what was officially called an "Airship Fighter".

Round about this time there had been a lot of chopping and changing and bursting-up and reassembling of aircraft firms and the Curtiss Airplane & Motor Co., Inc., had become a division of the Curtiss-Wright Corporation, so henceforth the great rivalry of Curtiss and Wright was extinguished in a coalition with which neither Glenn Curtiss nor the survivors of the Wright family had anything to do.

The Curtiss Co. also built a military monoplane which was called the Shrike. It had a 600 h.p. Conqueror engine and was said to be very fast but no figures were published in this country.

A short-lived firm called the Granville Aircraft Corporation, formed in 1933, from a firm which had existed a year or two previously called Granville Bros. Aircraft Inc., built an amazing apparatus called the Super Sportster racing monoplane which had a 900 h.p. Pratt & Whitney Hornet. The thing looked

very like a bumblebee. Its span was only 25 feet and most of that seemed to be taken up by the diameter of the motor and the cowling. The whole thing was only 17 feet 9 inches long.

The pilot sat in a minute cabin right up against the beginning of the fin. In one of those things Major James Doolittle, won the 1932 Pulitzer Trophy at an average speed of 252.6 m.p.h. Then in 1933 it was remodeled by the new firm and in it Jimmy Doolittle put the world's land speed record up to 294.2 m.p.h.

An interesting point here is that the land speed record was for several years slower than the records set up by float seaplanes. And today, only eight years later, a pilot with a very few months' training would consider himself insulted if he were asked to fly a fighter which did not do at least 350 miles per hour.

John Northrop was also out after speed and built for Frank Hawks of the Texas Oil Co. a single-seat monoplane with a 710 h.p. Wright Cyclone motor which had a cruising speed of more than 200 m.p.h. and a range of more than 2,500 miles. Here we had, if anybody had gone on with the development, the beginning of a long-range fighter, just the sort of thing that the R.A.F. wanted in Norway and in Crete, and had not got.

Another sporting monoplane which put up a fine show was the Wedell-Williams, in which Mr. James Wedell raised the world's landplane speed record to 305 m.p.h. In another of them Mr. Jimmy Haizlip won the Bendix Trophy Race and also put up a new transcontinental record from the Pacific to the Atlantic of 10 hours 19 minutes, which represented a speed of more than 200 m.p.h. from ocean to ocean.

In yet another of the type Colonel Roscoe Turner put up an east-to-west transcontinental record from New York to Los Angeles in 11½ hours, an average speed of 291 m.p.h. And on September 25, the same pilot in the same machine flew from Burbank, California to New York, which was the same course as James Wedell's, in 10 hours 5 minutes.

One of the novelties of 1934 was a modification of the Fairey Fox built by the Société Anonyme des Avions Fairey, in Belgium, fitted with a Hispano-Suiza engine of 750 h.p. The speed of the machine was about 230 m.p.h. and it was said to

have climbed to 5,000 metres (16,400) feet in 6½ minutes. This is I believe the only occasion on which Belgium comes into this discussion as having produced an original type of airplane, and it was done by a branch of an English firm.

A later variant of this machine was called the Fantôme and was fitted with the Hispano *moteur-canon*. About half a dozen of them were sold by the Belgian firm to Russia and two or three of them were sent to Spain by Russia during the Civil War where they were flown by specially picked Russian pilots. They were effective, but, because of bad maintenance, they were out of action long before the end of the War.

This was the first British airplane to be fitted with a cannon gun. And, curious as it may sound, now, the fact remains that it was never adopted by the R.A.F., although a British firm acquired a license from the Hispano firm to build the *moteur canon*. Not until late in 1940 did our Parliamentary Under Secretary for Air, Captain Harold Balfour, M. C., M. P., announce that we were using cannon guns and that they were doing good work.

Early in 1934 the Gloster Aircraft Co. Ltd., was taken over by Hawker Aircraft, Limited, part of the great Hawker-Siddeley combine. Late in 1933 the Gloster Gauntlet fighter had been selected as the standard single-seat fighter for a number of R.A.F. squadrons. This machine had a top speed of 228 m.p.h. with a Bristol Mercury radial air-cooled motor of 645 h.p.

THE DIESEL TRAGEDY

For some years past the Bristol Co. had been developing a Diesel motor. A Westland Wapiti on May 14, 1934, reached a height of 28,000 feet, which is believed to be still a record for compression-ignition engines. This one had a maximum of 430 h.p. which could be boosted to a take-off power of 470 h.p. Unfortunately neither the Commercial nor the Service powers were particularly interested in Diesel motors, so no farther developments took place.

Mr. Roy Fedden, the designer, stated publicly that for a matter of £200,000 a Diesel engine could be produced which on a weight-for-power basis, and on performance tests, would be

equal to the best electrically-ignited engines. But here, as in America, nobody was enough interested to put up the money.

Consequently we have all gone on with our petrol or gasoline motors which catch fire on the slightest provocation, where a Diesel would not. We have gone on with our electric ignition with all its cost and delicacy, and the need for extensive screening to prevent interference with radio, and additional complications, plus heavier fuel consumption. But at any rate the Bristol Diesel was the first to fly in a combat airplane.

During 1934 several British lightplanes appeared which had retractable undercarriages but they were not among Air Force equipment.

An interesting historical fact is that the first Supermarine Spitfire appeared in 1934. It was a single-seat low-wing cantilever monoplane, that is to say without wire bracing top or bottom. It had a Rolls-Royce Goshawk steam-cooled engine with condensers built into the wings. And it had a fixed undercarriage. Its armament was four machine guns. From this and from Mr. R. J. Mitchell's Schneider Trophy Racers the wartime Spitfire was evolved.

GERMANY'S AWAKENING

Germany had not yet got to the stage of throwing off all disguise and deliberately building combat airplanes, but a thing that strikes one on looking back through the records of the time is the number of firms in Germany which were openly making trainers. They were all more or less founded on the idea of the British Moth biplane or the British Miles monoplane and all had motors between 80 h.p. and 120 h.p. Some of them even ran up to 150 or 200 h.p.

They were sold quite extensively to various European nations, and they were used in Germany in the Sport-Flying Club groups, which were in fact hardly camouflaged at all, and were openly regarded as the beginning of training for a real German Air Force.

Another sign of the times was the foundation of the Henschel Flugzeugwerke outside Berlin. Henschel's are one of the biggest manufacturers of locomotives, railway rolling-stock, and

generally of engineering products in the world. They could not have come into the aircraft business with any idea of building a few dozen trainers.

Only a year or two later Henschel's were turning out two-seat fighters for general reconnaissance work. Their works were about the most up-to-date thing in the world at the time. The sheds were staggered in curious positions so that no attacking bomber could put a stick of bombs across two sheds in one run. Their underground shelters for the workspeople were excellent.

I was going round these works not long after they were built with one of the Directors and remarked to him jokingly that they seemed very conscious of the imminent danger of bombing. He said to me, quite sincerely, for he was of the better sort of Germans, "Don't forget that we are 800 miles nearer to Moscow than you are." I have been wondering lately whether that statement has recalled itself to him.

ITALY DOES SOMETHING

On October 23, 1934, Lieutenant Agello, of the Italian Regia Aeronautica, put the world's speed record up to 440.7 m.p.h. in a Macchi-Castoldi 72 with a Fiat AS-6 engine (that is two engines in line) boosted to give 3,100 h.p. We are now getting speeds higher than that from landplanes with less than half the horsepower, which only shows how much horsepower is absorbed by struts and wire bracing, and protruding undercarriages.

An amusing point hereabouts is that the first bona fide fighter designed in Germany was the Dornier Do-V4, which was built by the Dornier Flugzeugwerke, which had its head office at Zurich and its works and aerodrome at Altenrhein in Switzerland, just across the border from Germany. It was a very neat high-wing monoplane two-seater, and it had a Rolls-Royce Kestrel motor which gave it a speed of 196 m.p.h. at 11,000 feet. With a French Hispano-Suiza it was said to have a speed of 197 m.p.h. at 11,000 feet, not bad for a two-seater.

In the United States the Lockheed people produced the Electra, which is the direct ancestor of the Lockheed Hudson

which has done so well in the Coastal Command of the R.A.F. This was a low-wing twin-motor twelve-passenger monoplane. It was notable for the fact that it had a cantilever tail with a fin and rudder on each end of it. The main idea of these twin rudders was to ensure that if one motor stopped there would be a fin and rudder in the slipstream of the other to help the pilot to keep the machine under control. The Electra with two Pratt and Whitney Wasp Junior engines, each giving 400 h.p., had a top speed of 221 m.p.h. and a ceiling of 22,500 feet. With one engine it had a ceiling of 6,000 feet. Its cruising range was 862 miles. Altogether it was a good airplane. Its high performance on comparatively low power with a big load was caused largely by its being able to retract its undercarriage. Glenn Martin had also, by this date, produced a middle-wing twin-motor fighter-bomber with a retractable undercarriage. This was the type which was copied in Russia and used largely by the Russians in Spain. And it is the direct ancestor of the Martin Maryland which is doing good service with the R.A.F. in the Middle East.

One of the tragedies of American aviation at this time was the death in an accident, in an ordinary trainer with a pupil, of Mr. James Wedell, with the result that the Wedell-Williams Co. which had been promising so well ceased to exist.

ENGLAND RETRACTS

In 1935, the idea of the retractable undercarriage spread to England. A. V. Roe & Co., Ltd., the pioneer firm of the British aircraft industry, turned out the little twin-motor Anson monoplane with a retractable undercarriage. This has become one of the most famous machines in the world. It began with the idea of being a trainer to bring pupils on from single-motor craft to big twin-motor craft. But it turned out to be so good with its two Siddeley Cheetah engines of only 278 h.p. each that it was made into a Coastal Reconnaissance craft and equipped with a gun position aft so that it really became a twin-motor fighter.

Its reconnaissance crews in those days consisted of two pilots, a navigator and an observer. Later it was used as a

flying classroom and one pilot used to take up an instructor and five pupils in the hull. As a Coastal Patrol machine it naturally carried a smaller crew, and depth charges for the good of submarines. It did magnificent work for six years before being pensioned off as a trainer and nothing else.

Another combat airplane which appeared in its earliest form in 1935 was the Bristol Blenheim. It was known as the 143 and was an all-metal twin-engine low-wing monoplane. It had two Bristol Perseus sleeve-valve engines of 430 h.p. each.

There is a legend that this machine was built to the specification and order of the late Lord Rothermere, but the true story is that it was built as a Bristol Co. private venture, by Captain Frank Barnwell, who had designed all the Bristol machines up to that time. The fuselage only was shown at the Paris Aero Show in 1934.

In that year Lord Beaverbrook, Lord Rothermere's great newspaper rival, had bought a Lockheed Electra, so Lord Rothermere, in an access of patriotism, told some of his people to go and find him a British airplane to compete. They saw the Bristol fuselage at the Paris Aero Show and ordered one like it. When the machine was built Lord Rothermere presented it to the Nation. But, so far as I have been able to discover, he never flew it. From it, with bigger and bigger engines, developed the Blenheim and the Beaufort and the Beaufighter, all of which have done excellent work.

In 1935 the Fairey Fantôme appeared in all its glory, as a British product. It had an Oerlikon 20 mm. cannon gun firing through the air-screw hub, two Browning machine guns firing through the air-screw disc with an interruptor-gear, and it had two more Brownings in the lower wings firing outside the air-screw.

Another important production in 1935 was the Gloster Gladiator which with a Bristol Mercury motor of 620 h.p. turned out to be the finest biplane fighter the world had seen or now is ever likely to see. It is, for many of the type are still in use in the Middle East, a single-bay equal-span biplane, the centre section is carried above the fuselage by splayed-out struts and there is one pair of parallel struts on either side of the fuselage.

The whole wing structure is of metal, mostly steel, covered with fabric.

The undercarriage does not retract but the wheels are carried on single cantilever struts so that there is the minimum of head resistance. The ends of the inter-plane struts are sunk inside the fabric so that there are no outside junctions or nuts or bolts to interfere with the air flow. The engine is neatly cowled and everything is as clean as a biplane with a fixed undercarriage can be.

It carries four machine guns, two of them in troughs in the sides of the fuselage, controlled by interruptors, and two mounted below the lower wings on either side of the fuselage and outside the air-screw radius.

The top speed of the Gladiator with the Mercury IX engine of 830 h.p., and with a streamlined cowling, or conservatory, over the pilot, is 250 m.p.h. which is very good for a biplane. The stalling speed is 63 m.p.h. But the most remarkable thing about the machine is its rate of climb. It gets up to 5,000 feet in 1.9 minutes, to 10,000 feet in 3.8 minutes, to 15,000 feet in 5.8 minutes, and to 20,000 feet in 9 minutes. Its service ceiling is 32,000 feet, roughly 10,000 metres.

This explains why the Gladiator is still one of the world's best fighting airplanes, particularly for defensive work where it can go up high and dive on loaded bombers, a tactic which was used most successfully in the Spanish Civil War by the Spanish and Italian pilots in the little Fiat CR-32 biplane against the Russian-built Boeing-type Rata monoplanes, which were miles an hour faster.

In 1935 there appeared the first machine built by the Martin-Baker Aircraft Co. Ltd., which to many people seemed to have great possibilities. The designer, Mr. James Martin of Belfast, had evolved an entirely new system of construction, a simplified method of using steel tubes. The other moving spirit of the firm was Captain Valentine H. Baker, for a long time chief instructor at Heston Aerodrome and recognized as one of the most skilful pilots and best judges of airplanes in the country. The money for the experiments was found by Mr. Francis Francis.

Many most interesting airplanes were built in this 1934-35 period but unfortunately they were either light airplanes which had an astonishing performance, such as the Perceval Mew Gull which did 225 m.p.h. with a 200 h.p. Gipsy engine, or they were big flying boats or bombers, all of which are outside the scope of this work. Actually the light airplanes of the period between 1935 and 1939 contributed a great deal to the efficiency of the fighters of this war. So much was found out about the various effects of the air at high speed that those gentlemen who considered themselves serious designers of combat airplanes had to take notice of the results which were being achieved by the little fellows.

For example the Caudron C-460 monoplane with a 370 h.p. Renault motor put up a speed record for light airplanes of 314.2 m.p.h. and covered 1,000 km. (roughly 600 miles) nonstop at 291.2 m.p.h. and 1,000 km. at 276.9 m.p.h. Those are speeds which today would be considered good for fighters of approximately 1,000 h.p. But the regular French aircraft firms still seemed incapable of producing anything worth while.

The Germans were still producing small airplanes and big and highly efficient passenger machines but as yet no definite war machines.

In Italy the Fiat people had got their CR-32 biplane with only a 550 h.p. Fiat engine (water cooled) doing 242 m.p.h., nearly as good as our Gladiator, and a service ceiling of 26,240 feet (8,000 metres).

FAMOUS TYPES IN THE U. S.

In the United States 1934-5 produced the Boeing with a D-26A 600 h.p. Pratt & Whitney Wasp, which became quite famous. No performance figures for the U. S. Army Air Corps type were given out, but the Boeing 281, which was practically exactly the same machine built for export, had a speed of 235 m.p.h. at 6,000 feet, its best height. This machine had wire bracing top and bottom and spats over the wheels but did not retract its undercarriage. Considering that it was more than 200 h.p. short of the Gladiator horsepower, it was not a bad show.

This year the Curtiss Co. produced the Hawk Type 3, single-seat biplane with a 760 h.p. Wright Cyclone which retracted its wheels into the breast of the fuselage much after the style of the Grumman. It put up a speed of 244 m.p.h., which was still less than the Gladiator.

What America could do in the way of speed was well shown by Mr. Howard Hughes of Los Angeles who built a racing monoplane with which on September 14, 1935, he put up a speed of 352 m.p.h. in spite of having only a 700 h.p. Twin Wasp Junior engine. Barring the big radial engine this was one of the cleanest looking airplanes that had yet appeared.

The Lockheed people built a very nice low-wing two-seat fighter with the XP-9 730 h.p. Conqueror, but it was still only able to do 243 m.p.h. at 6,000 feet.

About the best effort in America was the Northrop XFT-1, a single-seat low-wing monoplane with a 750 h.p. Twin Wasp. It was credited with a top speed of 260 m.p.h. and a terminal velocity diving speed of 450 m.p.h. This machine had a fixed undercarriage with carefully streamlined pants. A similar machine in 1935 was credited with having its speed put up to 320 m.p.h.

THE HAWKERS

In England by 1936 the Bristol 142 low-wing twin-engine monoplane which was completed to the order of Lord Rothermere had become the Bristol Blenheim, middle-wing monoplane, which has since proved to be one of the most useful airplanes in the war. Though primarily designed as a bomber it soon showed itself to be equally useful as a multi-gun fighter.

In 1936 the Hawker Hurricane, a single-seat low-wing monoplane with a Rolls-Royce Merlin motor, made its first appearance. The Merlin must then have been giving 900 h.p.

At that time we were allowed to publish the performance figures for the Hawker Fury, which was then our first-line single-seat fighter. Its top speed was 240 m.p.h. at 14,000 feet, the best operating height of its Kestrel VI engine. In awe stricken whispers people who knew used to speak of the Hurricane with the Merlin as having a speed of something over 300 m.p.h. But it was a deadly secret.

The Hawker Hart with a Kestrel was doing 184 m.p.h. and climbing to 10,000 feet in 8 minutes, which was not bad for a two-seat biplane.

From the Hart was evolved a variety of two-seaters—the Hawker Hart Trainer was without guns. There was the Hawker Hardy, a general purpose biplane with guns and bomb racks and accommodation for cases of beer and all kinds of things that a two-seater does not have. There was the Hawker Hind, a hotted-up Hart with a supercharged Kestrel VI. There was the Audax, fitted with apparatus for exchanging messages with the infantry on the ground, and described by an old Cockney sergeant in the R.A.F. as, "Nothing but an 'Art with an 'ook' ", the hook being there to pick up the messages. There was the Hawker Hector which was the Audax with a twenty-four-cylinder H-type Napier Dagger air cooled engine. There was the Hawker Demon, purely a two-seat fighter which had a top speed of 200 m.p.h. at 4,000 feet. And lastly there was the Hawker Osprey, which was practically the same thing as the Hart but adapted for the Fleet Air Arm, with flotation gear, a sling-hook on top, and an arrester hook below. A pretty comprehensive lot.

Also in 1936 the first Supermarine Spitfire appeared. Unlike the Hurricane, which was built of steel tubing partly covered with aluminum, or rather duralumin, plating and partly with linen fabric, the Spitfire was a stressed-skin job, in which the metal covering was so riveted together that it took practically all the load of the tail-controls. The first to appear had a Rolls-Royce Merlin motor, a retractable undercarriage, and split trailing edge flaps.

Another airplane which became famous, the Fairey Battle, made its first public appearance in 1936. Primarily it was a three-seat day bomber single-motor monoplane. But during the fighting of 1940 it developed into a two-seat fighter and was even used for dive bombing, for which it had never been intended and was not suited. It had a Rolls-Royce Merlin motor which grew in power year by year, and naturally the performances of the machine went with it.

The last of the 1936 crop of any note was the Westland Lysander. This is a curious looking airplane. Its wings are placed high above the fuselage, they have a very small chord at the butt and then the chord splays outwards to the point where the spars join the struts which run to the bottom of the fuselage, then they taper again sharply towards the wing tips. It has slots all along the leading edge and slotted flaps all along the trailing edge and it has a high undercarriage which has a single cantilever leg on each side. With a Bristol Mercury IX of 700 h.p. it had a speed of 158 m.p.h. Purely as an Army Co-operation scout and message carrier the Westland Lysander turned out to be a very successful machine, for its job, and it has done well as a two-seat fighter.

THE GERMANS SHOW THEIR HAND

In 1936 the Germans came out boldly with a series of military aircraft. And they were fortunate in having a first class opportunity of trying out these types in real service conditions. The Spanish Civil War broke out in 1936 and the Germans managed to lend or lease all their new war types to General Franco's Nationalist Government.

The French, on the other hand, who had nothing worth talking about to give away, sold all the obsolete types of fighters and bombers on which they could lay hands to the Government, or Reds, who paid in hard cash for them out of the gold of the Bank of Spain, which had been removed to Paris.

France at this time was seething with Communism. The men were demanding a 36 hour working week and few of them were doing 24 hours honest work per week. The result was that the great French aircraft factories which should then have been building up large stocks of combat airplanes against the possibility of a European War, fell to pieces.

Men whom I had known for twenty-five years or more in the French aircraft business were broken-hearted at the way in which France was being let down, not only by the politicians, which everybody knew, but by the workmen themselves who would obviously be the first people to suffer if France were conquered. In fact things had got so bad by this time that even

when M. Blum's Government of the Front Populaire, which was most extremely Left Wing, effectually Socialised the aircraft industry by cutting it up into regional groups, little more harm remained to be done.

That was why when war broke out in 1939 France had no air force worth talking about. The French pilots were as gallant as ever but they had practically no airplanes and no armament. The result was that although during the period of the *Sitz*krieg, from the outbreak of war till June 1940, individual French pilots did very well in aerial jousting over the Maginot Line or the Siegfried Positions, they were almost used up by the time the storm broke on them.

By this time the Germans had their elementary trainers, masquerading as light sports planes, they had their advanced trainers with engines of 250 to 300 h.p. and some with twin engines —such as the Focke-Wulf Weihe, which had two 240 h.p. Argus inverted engines and had guns forward and amidships.

Dr. Heinkel had produced the He-5.1 single-seat fighter biplane, which with one 750 h.p. B.M.W. Hornet had a top speed of 250 m.p.h.

Henschel's produced a really fine single-seat dive bomber which with a Siemens radial motor of 700 h.p. had a top speed of 170 m.p.h. and which climbed to 1,000 metres (3,300 feet roughly) in 2.8 minutes.

Willy Messerschmitt at the Bayerische Flugzeugwerke at Augsburg produced the famous Taifun (Typhoon) which although a civil machine is of great historical importance. It had an Argus eight-cylinder inverted-Vee air cooled motor of 240 h.p. It had slots and flaps all along the wings. Its top speed was 186.3 m.p.h. Its cruising speed was 161.5 m.p.h. and its landing speed was only 44 m.p.h. It climbed to 1,000 metres in 3.15 minutes and to roughly 10,000 in about 13 minutes.

With four people and 50 kgs. (about 120 lbs.) of baggage its ceiling was 21,500 feet and its range at cruising speed was roughly 1,000 km. or 620 miles. That was the machine from which the Messerschmitt fighters were developed. Right up to the war it was quite the best all-round touring airplane.

A CONTRA-PROP FIGHTER

An interesting design for a combat airplane was introduced by Fritz Koolhoven in Holland in 1936. It was a cantilever monoplane in which the wing was not quite on top of the fuselage and not quite in the mid-wing position, rather one might call it a shoulder wing. The engine was underneath the pilot between the spars and on top of the centre of gravity, thereby minimizing the longitudinal moment of inertia. The pilot sat practically on top of the leading edge so that he could see down below him and all round and above. Thus he had an outlook of something more than three-quarters of a sphere. The engine drove, through ingenious gearing, two air-screws revolving in opposite directions as in the record-breaking Fiat, but in this case there was only one engine to do the driving.

Unfortunately, because of the miserable state of aircraft politics in France, the great Lorraine-Dietrich firm which was to have made the 850 h.p. engine for this job took about three years to get the gearing made, with the result that, although the prototype machine did fly, the gearing flew also, to pieces, and there was no time before the outbreak of war in which to get it right and consequently none was built.

Generally the machine was like Mr. Lawrence Bell's Airacobra even to having a cannon firing through the air-screw boss and having machine guns in the wings outside the air-screw disc, and having the pilot perched on the leading edge of the wing. And it had the immense advantage of having contra-props.

That advantage would have been great for several reasons. Besides dispelling torque, the two air-screws would have been much smaller in diameter than the one big air-screw on the Airacobra; consequently the machine guns could have been placed closer to the fuselage and so the weight of their ammunition would have been nearer the centre of gravity and it would have been that much more manoeuvrable laterally.

A curious thing is that neither in the United States nor in England did anybody pay attention to the advantages of the contra-prop idea. There are naturally great difficulties in arranging a gear-box to drive two air-screws in opposite directions, but the

advantages of having lighter and smaller air-screws and lighter pitch-changing mechanism, and abolishing torque makes worth while the overcoming of these difficulties.

Now that people both in the States and in England have reconciled themselves to the idea of the pilot sitting on top of the engine, as in the Airacobra, there is a possibility of developing the old Fiat idea of having two separate engines driving air-screws in opposite directions on the same axis, although that object may not be achieved in precisely the Fiat manner.

In 1936 the Savoia-Marchetti commercial monoplane which had been doing well on various European airlines came out openly as a fighter-bomber. It was tried out in Abyssinia. There was no need then for protective guns, as there was nothing up against it, but when it came into use largely in the Civil War in Spain it was fitted with two cannon guns on top, one firing forward and one firing aft, and another firing through the floor. These proved to be very effective, and the Spanish pilots used them habitually, after they had dropped their bombs, in attacking enemy transport on the road.

An interesting point about the tri-motor Savoia is that even in those days it could have started from northwest Italy and have carried a ton of bombs to London, and still have had enough gasoline to get back to Italy. A prominent performance calculator in this country has worked out that a Savoia bomber could start from Brest, drop 500 lbs. of bombs on New York City and still have enough gas left to get back across the Atlantic.

AMERICA SPEEDS UP SOME MORE

In the United States there was a marked advance in design in 1936. The U. S. Army Air Corps and the U. S. Naval Air Service began to take new equipment seriously.

For the Air Corps Curtiss built the YT-36 single-seat monoplane fighter, with a 1,000 h.p. Cyclone, to Air Corps specifications. It was the first of the American all-metal fighters and the first to have a retractable undercarriage.

Another excellent Curtiss production was the Y-1A twin-motor attack monoplane with two 1,000 h.p. motors. It was at that time the only twin-attack type in the world. It was de-

signed to combine high performance with long range and was particularly designed for high speed at a low level.

Much good was done to the design of combat airplanes during this period by the production of several very small racing machines by private enterprise to compete for quite high prizes offered at race meetings in the States. Benny Howard, and Miles & Atwood and Arthur Chester Crosby, and the Falkers and the Cee-Bee, and several others set up phenomenal speeds with comparatively low power.

A new firm about this time was the Seversky Aircraft Co. founded by Major de Seversky, a "White" Russian. His single-seater and general purpose two-seater were adopted by the U. S. Government. The latter, with only a 550 Wasp, had a top speed of 225 m.p.h. and a landing speed of 64 m.p.h., which was good.

Chance Vought also produced in 1935 the Corsair, a two-seat fighter-bomber with a 700 h.p. Twin-Wasp Junior. It was a low-wing monoplane with a retractable undercarriage and it was so good that the U. S. Navy ordered 54 of it.

Vought also produced an all-metal single-seat fighter developed from Northrop designs. This, with a 525 h.p. single-row Wasp Junior did 250 m.p.h. at 8,000 feet.

This was practically the same performance as that of the British Gladiator with 800 h.p. which, in simple arithmetic, means that we had to pay 300 h.p. to push a mass of undercarriage and wheels and an upper plane and the necessary bracing through the air, because otherwise the performances would have been about the same. The Gladiator scored because the service ceiling of the Vought was 28,000 feet and the rate of climb at 8,000 feet was 2,100 per minute. But the Vought carried gas for nearly 1,100 miles at cruising speed using only 50 per cent of its power, which was more than the Gladiator could have done.

About this time also Mr. Gerald Vultee, who for several years had been Chief Engineer of the Lockheed Company, produced a two-seat attack bomber, an all-metal low-wing monoplane with a 775 h.p. Wright Cyclone which had a speed of 237 m.p.h. at 11,000 feet and thus was fairly well comparable with the Fairey Fantome. But both types had ceased to interest the authorities when war broke out a few years later.

NAVAL FIGHTERS

In 1937 we come across the first combat airplane designed specially for the British Navy. This was the Blackburn Skua, a dive-bomber-fighter low-wing all-metal airplane built to Air Ministry Specification 04/34, which means that the specification was issued in 1934, so that the general scheme was already three years old when the machine appeared. It was the first monoplane to be built for the Navy's use and it had a Bristol Perseus sleeve-valve engine of 815 h.p.

As it was a brand new Navy type no performance figures were available, but it was generally considered to have about the same speed as the Battle. It has a retractable undercarriage, and the wheels, when retracted, fit into the part of the wings which folds back, so that the design of the undercarriage and the stub wing which carries it is a trifle complicated. All wings of Fleet Air Arm aircraft have to fold back so that the machine can go down the lift to the hangars below the landing deck.

Split flaps are fitted to act as brakes when dive bombing. Ailerons are set in from the wing tips instead of running right out to the end as in almost all airplanes. The reason for this is not clear unless it is to stop wing flutter.

Another peculiarity is that the fin and rudder are set forward of the tail plane, to stop spinning. The theory is that many airplanes spin because the tip of the tail plane blankets the fin and rudder. Apparently the theory works so far as the Skua is concerned.

The Fairey Co. produced in 1937 a very good two-seat day bomber-fighter low-wing monoplane with a Merlin called the P4/34 which was an improvement on the Battle. The figure 34 here indicates, as in the Skua, that the specification had been issued by the Air Ministry in 1934, which naturally means that the specification of the Battle was still earlier than that.

Unfortunately the Battle had been put into full production at the Fairey Works at Stockport and at the Austin Motor Co.'s factory near Birmingham. Although the P4/34 was better than the Battle it was not so much better that the authorities considered that the production of Battles should stop and the P4/34's go forward.

Actually the authorities turned out to be right, because when the war really got going the P4/34 would have been no more use than the Battle was. Either would have been equally obsolete.

The Gloster Co. had a similar piece of bad luck with the Gloster F5/34 a very attractive single-seat multi-gun low-wing monoplane fighter with a Bristol Mercury IX motor. It had a monocoque, or one-piece, fuselage, a retractable undercarriage and tail wheel, in fact everything of the best, but, having a radial motor, it could not compete with the speeds of the Spitfire and the Hurricane.

The Hawker Co. had the same thing happen to them with the Henley, a two-seat bomber-fighter monoplane with a Rolls-Royce Merlin. That was also a 1934 design, but it was not so far ahead of the Battle as to justify scrapping the jigs and tools and setting up a new lot for the Henley. Quite a fair number of Henleys were ordered, with the idea that they might come in as a useful alternative type to be completed by sub-contractors if necessary. But again we were lucky because, good as the Henley was, it was not up to the standard of performance which 1940 showed us to be necessary.

THE FINISH OF FRANCE

In 1937 France nationalized all the French manufacturers of military aircraft. The firms were arranged in groups regardless of what they were making, each group became a *Société Nationale des Constructions Aéronautiques,* of the West, of the South-West, of the North, of the Centre, of the South-East and of the Midi, which was the South, as the case might be.

The result of this Socialization was that the former heads of firms lost interest, because they lost the spur of competition. The managers became petty government officials. The workmen, deprived of the contact and inspiration of their bosses, or *patrons,* as they used to call them, became merely teeth on the cog wheels of the machinery. Production practically ceased.

There is official record that in one particularly bad month just before the war, the whole French aircraft industry produced twelve military aircraft.

Things were so bad late in 1937 or early in 1938, that when a friend of mine was going round one of these nationalized factories with the man who had been the *patron* of the whole firm, the workmen were lolling about smoking or playing cards. Some of them had taken a day off because they thought they would like to as the weather was fine, and anyhow they only had to work a 45-hour week. When their former boss came by the men did not even take the trouble to get up from their card game. Nor did they greet him with any signs of respect.

That was the spirit of France. Can you wonder that they had no combat airplanes, and that they collapsed as they did?

The only attempt at a first class combat airplane in France was the Morane-Saulnier 405, a low-wing monoplane with an 860 h.p. Hispano-Suiza engine. It had a top speed of 298 m.p.h. But even so the back part of the fuselage was covered with fabric. The French had not reached the all-metal stage.

THE FIRST GERMAN FIGHTER

In 1937 Willy Messerschmitt came out with his first genuine fighter. It was called the Bf-109 and it had a 950 h.p. Daimler-Benz twelve-cylinder inverted-Vee liquid cooled motor and a V.D.M. controllable-pitch metal air-screw. No particulars of its performance were available that year. All we knew was that it was very fast.

Four of these machines with Junkers Jumo motors, also twelve-cylinder inverted, but of only 640 h.p., flew in the Speed Race at the International Flying Meeting at Zurich over a course of 31 miles which had to be covered five times. One of them won it in spite of all the corners, at 255.5 m.p.h. Later in a race of 228 miles round the Alps the winner was a Bf-109 with the 950 Daimler-Benz and its average speed was 241 m.p.h. The best of the three with the Junkers engine did 233.5 m.p.h., which gives some idea of the speed of the machine. Another of the Bf-109's with the Daimler-Benz won the Climb and Dive Competition at Zurich by climbing to 3,000 m. (practically 10,000 feet) and diving down to 1,300 feet in 2 minutes 5.7 seconds, which shows a fairly fierce rate of climb.

Dr. Heinkel produced in this year the He-112 single-seat fighter with a 650 h.p. Junkers engine which had a top speed of 292 m.p.h. and a range of nearly 700 miles, which after all is only 2½ hours flying. The Heinkel two-seat dive bomber-fighter with a 910 h.p. Daimler-Benz (twelve-cylinder inverted-Vee) had a top speed of 248.4 m.p.h.

Henschel produced a general purpose high-wing monoplane rather like our Lysander, which with a 610 Siemens nine-cylinder radial had a top speed of 164 m.p.h.

Italy continued to make a number of beautifully finished airplanes which otherwise were quite undistinguished, except for the old Fiats and Savoias.

The Russians continued to make colossal multi-engined bombers but their achievement at this period was a single-seat fighter which was shown at the Paris Show at the end of 1936. It was called the ZKB-19. It had a Russian-built M/100 *"moteur canon"* evidently a copy of the Hispano-Suiza.

Here perhaps I may interpolate a note on Japan. The Japanese have never produced anything original. On the other hand they have not made "Chinese copies" of the best American or German or British airplanes. They have merely taken what struck them as being the most outstanding features of the airplanes of other nations and combined them into airplanes of so-called "Japanese" design. Unfortunately for them, what may be an excellent feature in an airplane for which it is designed may have the effect of spoiling another equally good feature in somebody else's design. The result has been that Japanese airplanes, although they remind one of a number of American and European airplanes, have no claims to originality. If they had made "Chinese copies" they would probably have had much better airplanes.

TRICYCLES

Just about 1937 an epidemic of tricycle undercarriages broke out. Small airplanes in England, America and in Holland were made with nose wheels. With the main wheels placed rather back, the machine landed and tilted forward onto the front wheel instead of onto a tail skid.

The idea had something to recommend it because a number of the bigger bombers and passenger craft had broken their backs because the pilots landed with the tail high up, and then when the tail plane lost its lift the weight of the machine would slam down on the tail skid and buckle the fuselage.

The trouble with many of the tricycle undercarriages was that when the pilot landed with his tail up the front wheel dug into the ground, or hit the ground hard, and collapsed and the whole thing turned over on its shoulder. Also there was the objection that the wheel itself and all its mechanism and its retracting gear, in a big machine, weighed much more than any tail skid.

There is interest in noting that 1937 saw the prelude to the industrial strikes in the U. S. A. which have been hanging up armament production in 1940-1. The Northrop plant, a subsidiary of the Douglas Co. which specialized on all-metal aircraft, was shut down by Mr. Donald Douglas because the employees struck in disregard of the wages agreement signed with the Committee of Industrial Organization in March, 1937.

Nevertheless John Northrop continued designing and produced the BT-1 two-seat dive bomber monoplane with a 750 h.p. Twin-Wasp Junior. A modified type was produced for the Navy also. This was Mr. Northrop's first machine with a retractable undercarriage.

In 1937 a new name appeared among makers of combat airplanes, North American Aviation Inc., the President and General Manager of which was Mr. J. H. Kindelberger, formerly Engineering Vice-President of the Douglas Co. Originally, in 1928, North American Aviation was a holding corporation for various aircraft and airline companies. In 1934 it was reorganized into an operating company. In 1936 new works were built at the Los Angeles Municipal Airport and a number of trainers were built. But in 1937 the firm turned out several types of light bomber and general purpose two- and three-seat fighter-bomber types. The most powerful of these, the NA-16-3 with a Wright Cyclone of 840 h.p. had a top speed of 238 m.p.h., a service ceiling of 27,000 feet and a cruising range of roughly 700 miles.

Another new type was the Seversky P-35 with a 950 h.p. Twin-Wasp. No official figures were published. The machine had partially retractable wheels and looked quite fast. But the published performances of the firm's two-seaters with similar undercarriages did not suggest any outstanding performance.

THE SHADOW SCHEME

I would add here, for historical reasons, that the British Government's scheme for the building of Shadow Factories which would make airplanes to the designs of "approved firms" was in progress in 1937. The first of the Shadow Factories made motors to Bristol designs and so to an extent were concerned in making some British fighters.

The Fairey Co.'s factory at Stockport and the Austin Motor Car Co. at Birmingham were turned on to make Fairey Battle single-motor monoplanes which were in fact already obsolescent when production in quantities began. When the war broke out they were obsolete.

Rootes Bros. built a great factory on the aerodrome at Speke, the municipal airport of Liverpool, where they made Blenheim bombers, many of which were afterwards converted into long-range fighters, and did excellent work.

Photographs of the insides of these enormous Shadow Factories and of the main factories of the leading British aircraft constructors, showing the work which was being done in them, were taken with Air Ministry approval by C. A. Sims, the official photographer of *The Aeroplane* newspaper and were published all over the world. Large-size reproductions were put up as a frieze round the Members' Dining Room in the House of Commons to impress on Members of Parliament that we were getting along with what was commonly known as the Panic Expansion of the R.A.F.

During 1937, General Milch, the Head of the German Luftwaffe, General Udet, his Chief Technical Officer, and General Stumpff, Chief of the German Air Staff, visited this country and, with General Wenninger, the German Air Attaché in London, were taken round these Shadow Factories to show them that we were already building up a big Air Force. The Ger-

mans were much impressed and their visit certainly had a good effect for at no time has the German Luftwaffe shown signs of underrating the power of the R.A.F. and the excellence of its airplanes and pilots.

GERMAN PRETENSE CEASES

In 1937-8 the Germans threw off all pretense and came out openly with a series of warplanes. And nearly all of them were good.

The Arado Flugzeugwerke of Brandenburg and Warnemunde, on the Baltic, which had taken over the works of the Friedrichshafen firm at Warnemunde, turned out a two-seat general purpose biplane with an 880 B.M.W. radial engine which was quite useful as an Army Cooperation machine.

Willy Messerschmitt's famous Bf-109 later better known as the Me-109 was produced in 1938. No figures were then available.

Fieseler produced a fantastic machine, the Storch, with slots and flaps all over it which could apparently get out of anything bigger than a tennis court and land at a standstill anywhere. It was intended purely for Army Cooperation so naturally its performance was not high. Its top speed with a 240 h.p. inverted Argus was only 180.4 m.p.h. but it landed at 25½ m.p.h., definitely an advantage in rough country.

The intense rivalry between Heinkel and Messerschmitt had already begun. Dr. Heinkel produced the He-112 single-seat fighter which with a 660 h.p. Junkers inverted-Vee twelve-cylinder motor had a top speed of 316.8 m.p.h. He also built a two-seat dive bomber which with a 910 Daimler-Benz motor had a top speed of 261 m.p.h.

There is interest in noting that the He-112 and the dive bomber both carried two machine guns firing through the air-screw and two in the wings outside the radius of the air-screw. The two-seater besides this armament had one machine gun on a movable mount in the aft cockpit.

Henschel produced a two-seat high-wing monoplane very like our Westland Lysander. With a 610 h.p. Siemens it had a top sped of 164 m.p.h. Henschel also made a high-wing single-

seat reconnaissance machine. But it was not of much account—one could hardly call it a fighter.

In Italy the Breda Co. produced a really good bomber-fighter monoplane with a retractable undercarriage and a Gnôme-Rhône engine of 870 h.p. which at 17,000 feet had a speed of 267 m.p.h. It was one of the best machines of its day in spite of having a radial motor.

The Fiat people having pushed the little CR-32 single-seat fighter biplane up to 242 m.p.h., now came out with a low-wing monoplane which had an 850 Fiat engine with a top speed of 299 m.p.h. and a stalling speed of only about 50 m.p.h.

Macchi produced a single-seat low-wing monoplane fighter with an 840 h.p. Fiat radial which did 313 m.p.h.

The Merdionali people of Naples built the Ro-A7 biplane with a fixed undercarriage with spats over the wheels which had a top speed of 211 m.p.h. As this machine only had a Piaggio motor of 390 h.p. this was remarkable, but not up to the needs of modern war.

The most remarkable Italian machine was the SM-79 which, although properly a bomber, was used so much as a ground attack fighter that it deserves to come into this story. On January 24, 1938, three of these machines left Rome and flew non-stop across the Mediterranean and the Sahara to Dakar, of which we hear so much nowadays in the papers—the distance was 2,670 miles—at an average speed of 245 m.p.h. The following day they flew across the South Atlantic from Dakar by Port Natal to Rio de Janeiro, 3,250 miles, at an average speed of 230 m.p.h. The engines were three Alfa-Romeo nine-cylinder radial air cooled supercharged of 750 h.p. each.

The machines were called the "Three Blind Mice". One of them was piloted by a son of Benito Mussolini.

In Holland Anthony Fokker produced a very remarkable single-seat fighter, the D-21, which with a Bristol Mercury engine rated at 760 h.p. had a top speed of 270 m.p.h., climbed to 1,000 metres (3,280 ft.) in 1.3 minutes, to 7,000 metres (practically 23,000 ft.) in 12 minutes, and had a service ceiling of 9,500 metres, something over 31,000 ft. With this it had a cruising range of 525 miles.

AMERICAN PROGRESS IN 1938

The year 1938 saw the introduction by the Bell Aircraft Corporation, Inc., of the XFM-1 Airacuda multi-gun fighter-monoplane with two 1,000 h.p. Allison engines driving pusher-screws. The first of these machines was built in 1937 but Government orders did not come through until 1938.

This is one of the most remarkable airplanes yet built. In front of each engine is a streamlined housing or office for a gunner and the guns are 37 mm. cannon.

Mr. Bell's argument, as given to me personally, was that having had a look in the nose of our big bombers and in those of the States he had come to the conclusion that they were like Piccadilly Circus—there was too much traffic going around in them. Therefore he decided to put his big guns outside. And as he could carry his gun mountings right back to his engines he could take up the recoil better there than he could in the nose of any ordinary twin-motor machine.

Besides the two cannon guns the machine also carries a bunch of machine guns in the nose of the nacelle. The result of this arrangement is that there is plenty of room inside the fuselage. Some of this is used to carry an auxiliary power plant to drive nine separate electric motors to supply power for the radio, lighting and heating equipment, engine starters, electric retracting gear, undercarriage, tail wheels, and for the operation of wing flaps.

Although this machine appeared in 1938 there do not appear to be large numbers of it in use in the U. S. Army Air Corps and none has been ordered for the R.A.F. Just what the objection to it is I have yet to discover, for in theory it seems one of the finest designs for a twin-motor pursuit ship which has been produced.

The Bell Aircraft Corporation was formed in 1935 by Mr. Lawrence Bell who was formerly Vice-President and General Manager of the Consolidated Aircraft Corporation when that firm moved its works from Buffalo to San Diego, California. Mr. Bell and his Chief Engineer, Mr. J. A. Woods, remained behind in Buffalo, and from the start concentrated on military aircraft. In 1936-7 they were building

parts for other people and had not produced a fighter of their own.

Another interesting machine which does not seem to have been approved is the Bellanca 28-90B, a two-seat fighter with a retractable undercarriage and with the wings braced downwards to a central mast or pylon. The upper bracing wires run to the top of the fuselage. This machine, with a 900 h.p. Twin-Wasp, attained a top speed at 5,000 feet of 280 m.p.h. and a service ceiling of 30,500 feet.

Another new machine now quite well-known but then unknown was the Brewster F2A-1. This was built as a ship-board fighter. It is really a low-wing machine, but the belly is still lower so that the undercarriage retracts into it. It has a Wright Cyclone of 850 h.p. and it is said to be very fast.

The Curtiss Co. produced an interesting machine in 1938 about which performance figures were withheld. This was the Curtiss P-40 low-wing monoplane with an Allison 1,000 h.p. liquid cooled engine. This was sold to the R.A.F. as the Tomahawk. A similar machine with a radial motor was called the Mohawk.

The Curtiss Co. also produced the 76-D (or A-18) twin-engine attack monoplane with two 850 h.p. Cyclones. This is an all-metal mid-wing monoplane and carries four guns in the nose of the fuselage in the ordinary way and one on top, but this armament has since been much altered. Its speed was 266 m.p.h.

The Douglas Co. turned out their first important war plane in 1937-8. The D-18 was a development of the well known Douglas DC-3 transport machine. It is a mid-wing cantilever monoplane with two Wright Cyclones of 1,000 h.p. each, and rumour said it had a speed of 225 m.p.h. It has internal bomb storage and there are gun pits in the nose, and above and below the fuselage aft of the wings.

The prototype of this machine won the U. S. Army Air Trophy in 1937. About 130 were then ordered for the U. S. Army Air Corps and big contracts were placed in the States for 1938. This machine seems to have been the ancestor or the direct parent of the DB-7 which is used in the R.A.F. either

as a bomber under the name of the Boston or as a night fighter as the Havoc.

Vultee produced the V-11, a three-seat attack-bomber monoplane with a 900 h.p. Wright Cyclone which was produced in fair numbers in 1938. A later type, the V-12, showed a distinct advance. It has four fixed electrically fired guns in the leading edge of the wings, two of rifle calibre and two .5 inch, besides one movable gun aft to fire upwards and one to fire downwards. Its speed at 18,000 feet is 238 m.p.h. and its cruising range 1,100 miles.

THE LAST LAP

The year 1939 up to the outbreak of war produced little that was new, but it made known to the world a good many types which were only coming along in 1938. In England an interesting machine was the Boulton-Paul Defiant, which carried no guns in front but had an electrically-driven four-gun turret just behind the pilot. This was the result of rival ideas inside the Operations Staff of the Air Force. One group believed that a broadside from a four-gun turret could be more effective and might be easier to deliver than a volley fired straight ahead from fixed guns. The effect of this is discussed in the last section of this book which deals with armament.

This year also appeared the Bristol Beaufort, a general purpose fighter-bomber monoplane with two Bristol sleeve-valve Perseus engines of about 1,000 h.p. each. It carries guns in the nose and in a turret on top and guns below. But it has been used chiefly as a torpedo bomber and bomber.

The Bristol Blenheim Mark IV, more commonly known as the long-nosed Blenheim, was developed into a long range fighter by putting more guns in the nose and underneath, and doing away with a lot of the bomb tackle.

The Martin-Baker Aircraft Co., Ltd., produced a single-seat fighter monoplane with a Napier Dagger air cooled motor which put up a surprising performance. Although it had a streamlined undercarriage instead of one which retracted, and although it only had about 900 h.p. as against 1,000 or more in the fighters with liquid cooled motors, its performance was said

to be about as good as the best. No official figures have ever been published. One of the peculiarities of the machine is that the top line of the fuselage is almost dead horizontal and the fuselage is practically the same depth from the nose to the tail; and it has a very small fin because the depth of the fuselage aft gets the necessary effect.

In 1939 official performance figures were given for the earlier type Spitfire. With a 990 h.p. Merlin II motor its top speed at 18,400 feet was given as 367 m.p.h. and it climbed to 11,000 feet in 4.8 minutes. The statement was made publicly that it carried eight Browning guns mounted in the wings outside the radius of the air-screw.

In France the position of affairs may best be judged by the fact that M. Béchéreau, designer of the historic Deperdussin monoplanes in 1912 and of the victorious Spads in 1917-18, was reduced to producing a two-seat light airplane with 60 h.p., for lack of anything better to do. The best French fighter, the Morane-Saulnier, managed to produce 298 m.p.h. out of an 860 h.p. Hispano-Suiza while our Spitfires were doing 367 m.p.h.

In Germany considerable progress was discernible. Herr Fritz Wendel flying a B.M.W.BF-113R monoplane, which was a very much hotted-up version of the familiar Me-109, with a special Daimler-Benz DB-601 motor, put the world's speed record for landplanes or seaplanes, to 481.4 m.p.h. And that still seems to be the record.

The Me-110 twin-engine attack monoplane with two Daimler-Benz engines of 1,150 h.p. each also appeared. It was said to have a top speed of 385 m.p.h.

Heinkel produced the 112 single-seat fighter with a 670 h.p. Junkers engine in competition with Messerschmitt. This had a top speed of 317 m.p.h. at 15,000 feet; but with the Daimler-Benz engine of 1,000 h.p. it went up to 358 m.p.h. at 12,500 feet.

Another notorious German machine, the Junkers Ju-87, known now as the "Stuka" dive bomber, also appeared before the war. This is a peculiarly ugly single-engine low-wing monoplane with a fixed undercarriage which carries its bombs

between its legs. It has one Jumo 211 engine of 1,000 h.p. Its speed on the level is 240 m.p.h. and its diving speed without the brake on is reputed to be 430 m.p.h.

The Germans had by this time organized an enormous shadow factory system of their own. Practically all the big aircraft plants in Germany had subsidiary assembly plants in other parts of the country. But the most important development in Germany, which we unfortunately had not developed in this country, was the Dispersal System. Few German aircraft firms made their machines from beginning to end in the same factory.

So far back as 1937 Helmuth Hirth, the famous German pilot of pre-1914 days, who had become an equally famous producer of airplane motors, told me that he had at least two small factories, widely separated, making each part of Hirth motors. That is to say, two factories would be making connecting rods and possibly pistons, and two factories would be making crankshafts and possibly crank cases, and they were arranged so that if any one factory were bombed the corresponding factory could speed up its output. And none of the parts was made in the main assembly plant. This idea was published in *The Aeroplane* paper, of which I was editor at the time, but it did not interest the politicians who were then in power.

I may add that I have never believed in the colossal size of the German Air Force which was so largely advertised in this country before the war in the hope of waking up the House of Commons and the people, on the principle of making our flesh creep.

Much of the German factory space and man-hours and material which could have been built into bombers for the invasion of England was expended on building super dive bombers which practically became a flying barrage to cover the advance of tanks and mechanized infantry, and on building the old Junkers 52 troop carriers which were used either for dropping parachute troops or to do crash landings on any sort of ground, with about twenty men packed inside.

The same amount of man-hours and material put into modern bombers and fighters might have made things very unpleasant

for us in England at the time of the retreat from Dunkirk, when they could have wrecked a good deal of our aircraft production and our railroads and our harbours.

On the other hand there would have been fewer dive bombers with which to drive the French from the North to the South of France, and fewer troop carriers and parachute carriers, and so the defeat of the French might have been less emphatic.

Either way, the German aircraft industry was evidently not big enough, in spite of all the boosting that had been done for it, to win the war in the air as the Germans had hoped when they struck against the Low Countries.

I will not say that those facts explain why Germany did not win the war, because Germany could not invade Britain and conquer this country in any case. But they do explain why Germany has not done a great deal more damage in this country and why Germany so decisively lost what is commonly called the "Battle of Britain", that is the fighting over the English Channel with which I will deal more fully in the next section of this book.

On the other hand the sacrifice of some of Germany's air power for the sake of land power may appear justified when one sees the immense area of Europe which has been conquered in consequence.

PRE-WAR ITALIAN PROGRESS

Italy's best development in 1938 was the Fiat CR-42 single-seat fighter biplane with an 840 h.p. fourteen-cylinder radial air cooled Fiat engine. For this machine a speed of 262 m.p.h. was claimed, and a service ceiling of 32,800 feet; but that was not good enough to beat the British Hurricane and Spitfire and anyhow, with two machine guns firing through the air-screw with interruptor gears, it had not a chance against our eight-gun fighters.

The Fiat Co. also produced the Fiat 50, a low-wing monoplane with the same 840 h.p. radial engine. This had four fixed machine guns which fired through the screw and two in the wings firing outside the radius of the air-screw. Its top speed, at 14,750 feet, is 299 m.p.h. and it cruises at 261 m.p.h.

on 50% power. Its absolute ceiling is 35,500 feet and it climbs to 16,000 feet in a little over 5 minutes; but it only carries petrol for 1.67 hours cruising. This machine in fact was not so highly regarded as a fighter by our pilots as was the slower but more manoeuvrable CR-42.

Macchi-Castoldi produced the C-200, also a low-wing single-seat monoplane, which has a top speed at 15,000 feet of 313 m.p.h.; but it only carries two machine guns and its ceiling is only 24,000 feet.

FOKKER ORIGINALITY

During 1937-8, Anthony Fokker produced two two-engine monoplanes which deserve notice although they have taken no part in the war. One, the G-1, had two Bristol motors each followed by a separate fuselage, or tail boom, according to how you regard it. The extremes of the tail booms each carried a fin and rudder and were connected by the tail plane and elevator. Between the two fuselages was a very well streamlined nacelle which carried .303 inch guns forward and aft and could carry quite a number of bombs. With two Bristol Mercury engines of 880 h.p. its top speed was said to be 300 m.p.h.

The other was the Fokker D-23 which also had two tail booms with the tail plane and the elevator between them, but in this machine the two motors, which might be either air cooled or liquid cooled, were placed in tandem fore and aft of the fuselage, one driving a tractor-screw and the other driving a pusher-screw. With two Italian Isotta-Fraschinis of 750 h.p. each its top speed was said to be 341.5 m.p.h. and its absolute ceiling was said to be 30,900 feet.

In the United States in 1939 the most interesting airplane, although it had not then been put through true Service trials, was the Bell P-39 single-seat fighter monoplane, with a 1,000 h.p. Allison. This is now known as the Airacobra. It was remarkable because it had retractable tricycle landing gear which was then a novelty, and the pilot sat in front and on top of the engine so that he could see down over the leading edge. It was designed to carry a 37 mm. cannon-gun firing through the hub of the three-blade air-screw which was driven by gearing on a large shaft which ran between the pilot's legs.

The performances of the Brewster and the Curtiss fighters were improved but nothing new was produced in single-seaters.

A novelty in bomber fighters was the Douglas DB-7 with two 900 h.p. Twin-Wasps. Several of these were supplied to the French Air Force during 1939. This appears to have been a development of the Douglas B-18A bomber, but it had more power and was reported to do a good deal more than 255 m.p.h., which was the best speed of the 18A before it became the Boston as a bomber-fighter or the Havoc as a night-fighter in the R.A.F.

Another Douglas type is the 8A, a two-seat attack monoplane with a single Cyclone of 860 h.p. It carries five rifle-calibre guns, four in the leading edge of the wings and one on a swivel in the gunner's cockpit. Its top speed is 255 m.p.h.

Towards the end of 1939, after war had broken out, the Lockheed Co. admitted that the Lockheed 14, a twelve-passenger commercial transport with two 750 h.p. Hornets, was being used as a war machine by the R.A.F. but for war purposes it was fitted with two 1,100 h.p. Cyclones.

Also we learned of the existence of the Lockheed XT-38, a single-seat twin-engine twin-fuselage all-metal monoplane with retractable undercarriage and two 1,000 h.p. Allison twelve-cylinder Vee liquid cooled engines driving Curtiss electrically-controlled air-screws and fitted with Fowler flaps. The prototype of this in 1939 flew from March Field, Cal. to Mitchel Field, New York, in a little over 7 hours. Even admitting that there was a howling gale blowing in the same direction, that works out at considerably more than 400 m.p.h. A year later the XT-38 was adopted by the R.A.F. and was called the Lockheed Lightning. But at the time of writing in the middle of 1941 none of these seem to be in the English sky.

And that is the end of the history of the development of combat airplanes up to the outbreak of war. We will now proceed to consider briefly the effect of all this development on the types of 1940-1, and the lessons which we may learn from them.

Part III

WAR DEVELOPMENTS

After the declaration of war there was practically no air fighting in the ordinary way. During 1939 the French sat in, behind and sometimes in front of their much advertised Maginot Line. The British Expeditionary Force prepared for itself defensive positions facing the Belgian Frontier and joined onto the Maginot Line.

German Headquarters were established at Wiesbaden, only a few miles from the Maginot Line, and the French could have bombed the Grand Staff to pieces if they had felt like doing it. But Wiesbaden is one of the world's most beautiful health resorts, and possibly the bombing of Wiesbaden might have excited the bombing of Harrogate or Bath or Cheltenham where, according to popular belief, various government departments had established themselves in luxury for the duration of the War. In fact this popular belief had good grounds because the English papers published numerous letters from people who had been dispossessed of suites in English Spa hotels which they had engaged with the idea of dying there in peace.

Although, as I have said, British industry had not at the outbreak of war recognized the importance of Dispersal as a policy —which they adopted enthusiastically after a certain amount of bombing—the British Government had apparently organized a most elaborate Dispersal Scheme for themselves before war broke out.

Anyhow we did not bomb the German capital and they did not bomb ours. But the Fairey Battle, already described as having been built to a 1933 specification, was sent over the German frontier to photograph the Siegfried Positions, commonly known as the Siegfried Line, and to photograph troops wherever they could. The Battles were excellent airplanes but they were old and slow, by contemporary ideas, so that they were shot down in numbers which were disproportionate to the results achieved. Consequently some of our Hurricane and Spitfire fighters made a habit of patrolling the air over the region which was being photographed.

Likewise the Germans sent photographic machines over our side to photograph our positions and they were also shot down and so were German fighters which escorted them.

The result was that a certain amount of jousting, rather than serious fighting, took place between the high-speed fighters of the belligerents. Ours were mostly Hurricanes. The Spitfires were not used much in France because we were keeping them at home in case of a big bombing attack, and so that we might not show our hand too openly to the Germans. The Hurricane was well on top of the Messerschmitt 109.

The French, who had practically no fighters of their own, used mostly Curtiss fighters. They behaved splendidly. They had an excellent climb, were very manoeuvrable and were quite fast enough to catch the Messerschmitts if they happened to be high enough up to add gravity to their horsepower. But the fact soon became evident that they did not carry enough guns. The Messerschmitts only carried six but that was too much for the Curtisses, and the Messerschmitts made a very poor show against our eight-gun fighters.

During this period there seemed to be an understanding between the German High Command on one side and the British and French on the other that there should be no bombing of one another's territories. In both air and sea warfare the combat airplanes had little to do, but they had to be constantly on the alert in case any bombers trespassed inland.

Then, as the German bombers took to attacking our convoys up and down the North Sea close to the English Coast, which were escorted by very lightly armed Avro Anson twin-motor reconnaissance machines, squadrons of combat machines were stationed along the coast ready at call of radio to dash out and attack German bombers which were interfering with the convoys. In this way quite a number of enemy bombers were destroyed.

Fighters squadrons were also stationed in the far North of Scotland and in the Orkneys and Shetlands to attack enemy reconnaissance machines which ventured up there in search of the British Fleet. The first real chance for the fighters was when several German reconnaissance bombers attacked ships

at anchor in the Firth of Forth near the Forth Bridge. A squadron of Gladiators swooped on them and shot down several.

This squadron happened to be a Scottish squadron of the Auxiliary Air Force, commanded by a Glasgow lawyer. He shot down a German bomber on the Lammermuir Hills south-west of Edinburgh. The pilot landed without killing anybody and was quite pleased with himself till he was told that he had been shot down by an amateur aviator who was a lawyer. The story is that he burst into tears because being shot down by an obsolete biplane was bad enough, but being shot down by a lawyer was more than he could bear.

I am sorry to say that this gallant lawyer, after distinguishing himself in many air fights thereafter, was himself killed on active service.

A comic incident in this fight which has nothing to do with this treatise concerns a pupil in a Moth biplane trainer who had flown down from Perth to disport himself over and around his father's house in Edinburgh. He was peacefully crossing the Firth of Forth when the fight began and he found himself surrounded by Gladiators doing shrieking dives from the sky and German bombers doing apparently impossible banked turns near the water, and anti-aircraft guns banging from the shore and shells and bullets flying in every direction. Fortunately he was able to find his way out of the battle, but his visit to Edinburgh was postponed.

A tragic affair was that of a group of officers and men who were standing on the deck of a destroyer watching the fight when one of the German bombers dived at the deck and machine gunned them. Two or three people were killed.

An interesting fact is that although a number of the Germans flew over the city itself, very low over the houses, none dropped any bombs. Actually the first bomb dropped on British soil was dropped near the shore of one of the Shetland Islands. Legend has it that a rabbit was the only casualty.

A contingent of the R.A.F. known as the Advanced Air Striking Force was sent to France, independent of the Army Co-operation Squadrons. The A.A.S.F. included both bombers

and fighters. The first serious work of these British fighters came when the Germans attacked Holland and Belgium and broke the French Army at Sedan. Then everything in France that could fire a gun, Hurricanes, Spitfires, Battles, Lysanders and Blenheims, tried to stop the progress of the German bombers and dive bombers. They were driven back at first by sheer weight of numbers.

Then came the great retreat to Dunkirk when the Germans, having pushed the French aside to the South, concentrated their strongest force on destroying the British Army in Belgium. Unfortunately from their point of view, these actions were fought within the radius of action of British bombers flying from their own aerodromes in England.

Without bringing down any of the fighter squadrons from the North, where they were kept in case the Germans tried big scale bombing of our Midland and Northern manufacturing cities, every other available squadron stationed on aerodromes in the South-East, concentrated on destroying the German dive-bombers in particular, which were doing their best to destroy the British Army on the ground.

The slaughter among the dive bombers was terrific. And a large number of the Germans' heavier bombers which were trying to bomb our rescue ships were also destroyed. The losses among the British fighters were extraordinarily small. Naturally no exact figures could be got for the German losses but at a moderate estimate the Germans lost four, or perhaps five, machines for every one which we lost.

A new terror was added to the German dive bombers by the sudden appearance during this battle of the Boulton-Paul Defiant, which has already been described earlier in this work. Instead of attacking the tail of the Stukas in the orthodox manner, these machines slid down alongside them and blew them asunder in the midst with a broadside from their four turret guns. It was wholly a surprise form of attack and it worked admirably for that period of fighting.

Later on the Germans became wise to the Defiants' methods and the German fighters took to attacking it head-on, where, as already described, it had no guns. Consequently though the

Defiant was still good against dive bombers it was not so good against well flown high-speed single-seat fighters. Consequently the type was withdrawn from daylight fighting and, with altered armament, it has been used and is being used as a night-fighter.

THE BATTLE OF BRITAIN

This treatise is primarily concerned with the combat airplanes of all nations, though necessarily it deals in more detail with American and British aircraft than with those of other nations because they are better than the aircraft of any other nation and there are more of them. But a short dissertation on the Battle of Britain, which is the name given to the heavy fighting over the English Channel and the Southern Counties of England in August and September 1940, may be of interest to American readers.

The attacks were made by the Germans with the idea of driving our fighters out of the air, smashing our fighter aerodromes, and then bombing our South Coast so that an invading force could land.

On our side nearly all the fighting was done by the Hawker Hurricane and the Vickers Supermarine Spitfire. Both had the Rolls-Royce Merlin engine which gave at that time about 1,100 h.p. Both were armed with eight Browning machine guns, four in each wing firing outside the air-screw disc.

The top speed of the Spitfire was officially 366 m.p.h., but many of them had been faked by their pilots and ground crews to do more. And though the speed of the Hurricane was supposed to be 335 m.p.h., some of them exceeded that. On the other hand there were naturally slow machines of both makes.

So long as the Junkers Stuka dive bombers were used the Boulton-Paul Defiant with the four-gun turret aft and no guns in front was a useful weapon. But it was slower than, and it could not fly so high as, the Messerschmitts, and so one can say that practically all the fighting was done by the Hurricane and Spitfire.

The German fighters were the Messerschmitt 109 and the Heinkel 113 single-seat fighters, both of which had a cannon gun firing through the hub of the air-screw, and two machine

guns in the fuselage, firing through interruptor gears. Then there was the Messerschmitt 110, two motor two-seat fighter which had two fixed cannon guns and four fixed machine guns in the nose and a single swivel-gun aft.

Their bombers were the old familiar Heinkel 111, the Dornier 215 and the Dornier 17 as heavy bombers, and the Ju-87 (Stuka) as dive bomber and the Junkers 88 a twin-engine dive bomber. The Heinkel 113 was supposed to have a speed of 380 m.p.h. but did not prove to be materially faster than the Spitfire. The Me-109 had about the same speed as the Spitfire.

The Organizers of Victory

Apart from the splendid fighting quality of the men and the inspiring leadership of the Commanders, all the way from the formation leaders up to the High Command, the British victory was due to two factors. One was the inspiration which prompted somebody, whose name has not yet been made known to history, to put those eight machine guns in the wings of our fighters; and secondly to the thoroughness of the tactical training, both in minor and major tactics, which our fighters had before the big battle began.

The Air Officer Commanding-in-Chief Fighter Command was, from July 14, 1936, Air Chief Marshal Sir Hugh Dowding, G.C.V.O., K.C.B., C.M.G. During 1941 Sir Hugh spent many months in the United States handing on to the U. S. Army Air Corps and to U. S. aircraft manufacturers the lessons which we had learned in the Battle of Britain. He remained A.O.C.-in-C. Fighter Command until the end of 1940 when the fighting had ceased.

The official history of this period of fighting, published by H. M. Stationery Office, indicates that the brunt of the battle was borne by No. 11 Group, which the last Air Force List issued to the public before the war shows to have had its Headquarters at Uxbridge near London. At the outbreak of war Air Vice-Marshal E. L. Gossage, C.B., C.V.O., D.S.O., M.C., commanded this group. He had been our Air Attaché in Berlin some few years before the war and knew the Germans and their equipment intimately. He was responsible for the training of

this group before the war. Later he was appointed to command the whole organization of Barrage Balloons.

Air Vice-Marshal K. R. Park, M.C., D.F.C., who had been Senior Air Staff Officer to Sir Hugh Dowding before the war, and was therefore largely responsible for the tactical training of all the fighter squadrons and for the strategic disposition of the fighter stations, took over No. 11 Group and commanded it from the beginning to the end of the Battle of Britain. Some years before the war, Air Marshal Park, as an Air Commodore, was our Air Attaché in Buenos Aires. His duties covered the whole of the South American Continent, so he is well known not only to the air officers of the South American nations but to many officers of the U. S. Army and Navy.

After the war had been in progress some time the western part of the area covered by this Group was made into a new Group, No. 10, which was put under the command of Air Vice-Marshal Sir Christopher Quintin Brand, K.B.E., D.S.O., M.C., D.F.C., a South African officer, who had a great reputation as a night-flying fighter in the last war. He had been knighted for being, with Lieutenant Colonel Helperus van Ryneveld, now Sir Pierre, and Chief of Staff of the South African Army, another famous South African fighting pilot of 1914-18, the first to fly from England to Cape Town.

On the other side of No. 11 Group was No. 12 Group, commanded by Air Vice-Marshal T. O. Leigh-Mallory, D.S.O., who is shown in the last Air Force List published before the war as commanding No. 12 Group at Hucknall, near Nottingham.

After the Battle of Britain was over Sir Hugh Dowding was awarded the Grand Cross of the Order of the Bath, of which order he was already a Knight, and the three Air Vice-Marshals who commanded Groups 10, 11, and 12 were made Companions of the Order of the Bath. From which we may judge that their services during and before the battle were recognized.

Apart from the excellence of the British pilots in their minor tactics, British superiority was shown in major tactics, such as the manoeuvring of wings and squadrons. When once a squadron was in contact with the enemy naturally it broke up and the affair resolved itself into individual combats, man-to-man. In

the manoeuvring of wings and squadrons as a cohesive force the direction of the High Command worked precisely as did the handling of cavalry in previous wars.

Perfect organization was needed in getting the squadrons off the ground. Modern airplanes which have such heavy loads (eight guns and say 3,600 rounds of ammunition for each is a lot of weight) only carry a limited quantity of petrol and therefore can only remain in the air for a short time. Anything in the way of a "standing patrol", that is to say cruising up and down over a certain space, is impossible. Therefore the squadrons sit on the ground till they are signalled off and are directed to a certain part of the sky.

Even so a lot of time and gasoline was wasted in hunting for the enemy, because although the radio-location device had been developed at that time and helped enormously in telling us . . . (censored) . . . the direction in which German forces were heading, we had neither enough instruments nor enough people drilled in using them to deal with the variety of directions from which the enemy came and in which he went. Now, some nine months later, as the result of our night-fighting experience the results are very different.

At that time every squadron had to be ready for action at short notice, but the tension on the pilots' nerves had to be relaxed. They could not all be expected to sit in their machines ready to take off at a moment's warning. In consequence squadrons were kept in three states. Those "In Readiness" were practically ready to take off at once. The next lot, which were called "Advanced Available" were kept ready to move up to the "Readiness" stage as soon as those squadrons took off.

The third lot were called "Normal Available".

Thus when the Readiness squadrons went off the Advanced Available squadrons proceeded to a state of Readiness and the Normal Available moved up to Advanced Available.

Behind them were squadrons which were logged as "Released" which meant that they would not be ready to operate until a definite time and that the flying personnel could amuse themselves while the technical personnel were fettling up the machines.

When action seemed very near Readiness squadrons were ordered to "stand by" and then the pilots sat in their machines with all their equipment on ready to take off, so that they only needed to have their engines started to get away.

I happened once to arrive at a Fighter Station just when all the flights were in Readiness. As I started to drive round the periphery of the aerodrome with the Commanding Officer the signal went for the flights to take off. They went away just as if somebody had pressed a button when the warning went. Before we had driven half way round the aerodrome all the sections of the squadrons were away and climbing up to join the squadron formation. The performance was about as quick as the turning out of a fire brigade.

Obviously the officer who is directing operations arranges his organization so that he does not send all his squadrons at once to attack one wave of raiders, and then find himself with a lot of his squadrons on the ground rearming and refuelling, and others in the air with little petrol left, just when another wave of raiders is coming over.

Tactical Training

On the whole the minor tactics of air war have altered but little since 1918. The most elementary form of attack is, if one has a faster machine or the advantage of height so that one can add gravity to horsepower, to dive on the enemy's tail, with the sun behind one, so that the enemy's aft-gunner, if any, may be dazzled, and just fill the enemy's fuselage with metal. But in these days of enormously high speed and of much higher fire power other methods of attack have been cultivated which were at any rate unusual in 1918.

For instance, one reads of head-on attacks. Obviously in the heat of battle two men may fly straight at one another, each risking collision in the hope that his fire will put the other man out and cause him to dive before the collision happens. The man who is hit will almost always fall forward onto his controls so that the machine will dive. In battle, if neither man is shot down, the pilot who holds the upper berth, because he is diving at the other, will probably pull up and pass over his enemy before

they collide. Similarly when a machine attacks from the beam, or from the forward or aft quarter, there is great danger of collision.

Consequently when the very fast machines were first put into the hands of pilots there were grave doubts about allowing practice with camera guns in such tactics. But as the pilots became more expert in the use of their machines such tactical practice was allowed, if not exactly encouraged at first. But there is no doubt that such training accounts largely for the superiority from the very start of the British over the German pilots.

The speed and ease of manoeuvre of the British aeroplanes and the practised skill of the pilots enabled them to keep out of range, or the line of fire, of the German cannon guns, with which our men were not equipped at first. And with their greater experience they were able to nose in on the blind spots of the German bombers and the weak spots of the German fighters.

In spite of the improved hitting power of the modern machine guns over those of 1918 the tendency of pilots is to get as close to their targets as they can before firing. There always have been and there always will be pilots who open fire at half a mile with a rifle-calibre machine gun, in the hope of hitting something. But the really experienced fighter pilot likes to get within very close range . . . (censored) . . . of his target if he can. And if he has the luck to do so he probably will have to "fly through the bits".

The official history records that one Hurricane pilot during the Battle of Britain fired at a faster machine than his own which was about to get out of range and hit it at 800 yards. This slowed it up and he put another burst into it at 500 yards. And then he finished it with a burst at 25 yards.

Another queer story is that of a Hurricane pilot who broke off a fight because his engine cooling went wrong and was returning home when he came across a single Me-109. He stalked it out of the sun, and shot it down at 500 yards. Giving him full marks for good judgment, there must have been a lot of luck about too.

After their heavy losses in the early stages of the Battle of Britain the Germans took to using heavier and heavier armour,

but the R.A.F. always had the upper hand, in spite of their inferior numbers. Incidentally much credit is due to those aircraft firms which modified their machines, fitting new and heavier armour and such things, in almost impossibly quick time while the battle was still going on.

In the Battle of Britain we were specially favoured by weeks of wonderful fair weather which made the defeat of the enemy easier. On the other hand it also allowed the enemy to see our fighters before they arrived and it enabled the enemy to keep formation and so maintain his fire power in a way which would have been impossible if the weather had been cloudy.

The probability is that if there had been heavy cloud-banks about, in which aircraft could take cover, a far larger number of enemy bombers would have got through than did so.

From the time when the flights leave the ground until they actually sight the enemy, they are controlled through radio telephone by the Controller at the station from which they are working. But when once they are in the fight the rest is their own affair. Radio-location is discussed in the section following.

A point to be remembered here is that before the war there was no radio-location and the Observer Corps, who have to do their locating by eye and ear, were never at full strength, whereas during the Battle of Britain there was quite a large amount of radio-location and there were far more Observer Posts at work, and the wonderful weather was all in favour of the spotters. Nevertheless nobody can deny that the work of the observers, the control rooms, and all the auxiliary services which directed the pilots to the enemy was superb.

Battle Formation

Before the war the standard squadron formation was made up of three flights of three machines each. With these nine a variety of formation could be made from "Squadron Vic" in which one machine led with four machines in Vee formation behind it, to line-ahead or line-abreast, or the more familiar formation of three machines leading with a flight of three on each side of it and slightly behind.

When war was declared and squadrons were brought up to strength the standard fighter squadron consisted of twelve machines. These can be used either as two flights of six or three flights of four. If the flights of six are used then there are three sub-sections of two each. If flights of four are used then there are two sub-sections of two each in each flight.

The basic idea is that the fighter pilots shall work in pairs. Each has his mate so that each can keep watch on the other's tail against enemy attack. That is to say that if one man is busy chasing an enemy machine then his mate will follow, keeping an eye meantime on whatever else there may be in the sky, and himself taking up the chase if the other man misses his shot. And, naturally, so far as possible the two keep together.

When the four-machine formation is used, as a rule three of the machines fly in the usual broad-arrow pattern and the fourth machine "weaves" about the sky either above and behind the other three or below and in front of them. That means that he flies to-and-fro crosswise on their track banking as he turns and keeping an eye on the sky above and behind them. The reason for this is that in the modern single-seat fighter, in which the man is tied down by parachute harness so that he can hardly turn his head, and is covered up to the top of his head at back by armour against direct attack from behind, he has practically no chance of seeing anything of the sky above and behind him. But he can look directly up and consequently, in a machine which turns and banks cross-wise on its path, does have a chance of seeing what there is above and behind.

Consequently, the machine which is told off to do the weaving is in effect a scout or lookout, like the cavalry vedette of past wars.

Sometimes, chiefly for compactness in handling the flight when travelling, the fourth machine flies behind the leader and between the two wing machines. This is called being "in the box". In a single-seat formation the pilot of the machine in the box can do nothing unless one of the wing machines breaks away and he takes its place. But in a formation of two-seaters the aft gunner of the machine in the box brings a third set of guns to bear on any attack from behind.

How the Battle Went

The Battle of the Channel really began on August 8 with attacks on shipping convoys by dive bombers. These were easily put out by our fighters. After that between August 12 and 18 Dover and Portsmouth and Portland were attacked and some hundreds of aircraft were sent to put our fighter aerodromes in the South and South East of England out of action. On August 15 and 18 the R.A.F. shot down 256 German machines. In the ten days August 8 to 18 the Luftwaffe lost 697 aircraft and we lost 153 machines from which 60 pilots were saved.

Today there can be no harm in saying that several of our fighter aerodromes were put completely out of action, but there was always accommodation at other aerodromes within a short distance.

After that there was a lull for about a week and on August 24 new raids started. The attack was now dispersed along the coast. Also the number of German escort fighters was increased and the size of the individual bomber formation was decreased. The covering screen of fighters flew at great heights, up to 25,000 feet or more. And the bomber formations were escorted by a screen or box of fighters, which generally flew slightly above the bombers sometimes ahead and sometimes behind.

The official history admits that sometimes these formations broke through the forward screen of our fighters by sheer weight of numbers and reached their objectives in spite of heavy losses. One of these I imagine must have been that notable attack on Croydon when the bombers got through apparently unhindered, but not one of them got back as far as the English Channel.

Probably the biggest day's attack was August 30 when 800 aircraft attacked nine of our aerodromes in a desperate effort to put them out of action. The idea obviously was that if our fighters could be put out by destroying enough of them and by destroying their aerodromes, the bombers would have an easy journey to London and our great industrial cities.

But what the Germans did not realize was that most of the fighting was being done by No. 11 Group in the South-Eastern Fighter Sector, reinforced in emergency from the West and North East. We had to keep our East Coast and Northern fighters up to strength in case of a big raid on our industrial centres in the Midlands and the North.

The fact that no such attack was made is the best proof that the German Air Force was nothing like so big as it was supposed to be. If the Luftwaffe had the strength for such an attack they lost the chance of the year by not making it. On the other hand our strength in fighters was obviously very much greater than the German High Command expected.

Whether the Germans thought that they had destroyed enough of our fighter aerodromes or not, the main attack on London began on September 7. For a week the raids continued and considerable damage was done in and around London. There were big fires at the docks and one bomber penetrated so far as to bomb Buckingham Palace. The official estimate is that about 30 Germans reached central London out of 350 which attacked the South Coast and the Thames Estuary.

The biggest attack was on September 15 when 500 German airplanes fought our single-seaters all the way from the London suburbs in the West down to the coast of France, and from the East all down the Thames Estuary. On that record day the Germans lost 188 machines. The record week of fighting was that between August 10 and August 17 when our fighters destroyed 214 German fighters and 281 German bombers, making a total of 495 German airplanes destroyed in a week. In the same period the Germans shot down 115 of our fighters and 31 of our bombers, making a total of 146. Out of these, 46 of our fighter pilots were saved.

For historical reasons I would record here a statement, which has never been either officially denied or officially confirmed, that on the night of September 16, 1939, R.A.F. scouts discovered that the Germans were holding a full dress rehearsal of the Invasion of England. There is just the possibility that it was intended to be the first stage of a serious invasion. In any

case R.A.F. fighters and bombers and units of the British Navy caught the rehearsing fleet some five miles off the French coast and hewed it in pieces.

Whatever the facts may have been, such is the version commonly believed in the R.A.F., and we do know that the Germans suffered great losses at British hands at that time.

The result of it all was that between September 6, when the new phase started, and October 5 the Germans lost 883 airplanes. Between September 11 and October 5 No. 11 Group alone destroyed 442 enemy machines, without allowing anything for those which were so badly damaged that they sank at sea on the way home or crashed on landing.

The proportion of losses was fantastic. On September 27 No. 11 Group brought down 99 German airplanes out of a total for the day of 134. They lost 15 pilots, which means a 6-1 proportion. On September 30, 32 enemy aircraft were brought down for the loss of two of our pilots. And on October 5 we lost one pilot for 22 enemy machines brought down.

Three times during that period a solitary Hurricane flown by a Sector Commander—who was out watching what his people were doing instead of sitting in the Control Room studying it all on a map—succeeded in making enemy bombers drop their bombs away from their targets.

Between August 8 and October 31 when the attacks in daylight ceased altogether, the Germans lost 2,375 airplanes. That figure is for machines which were strictly verified as having been shot down. And our system demands that evidence from another Squadron or from the anti-aircraft gunners or Observer Posts on the ground are needed before a victory can be logged. The figures do not include those which stagger back home and crash on landing or sink in the Channel on the way back.

Against that the R.A.F. lost 375 pilots killed and 358 wounded.

Compared with the losses in the Infantry in the last war, those losses appear trivial. And compared with the total of personnel in the R.A.F. today they represent a small percentage, especially when one reckons on the output of pilots from Canada and Australia and the Colonies and from British train-

ing stations in the United States, from which we can safely reckon on getting thousands of pilots a year, without reckoning men trained for air crew work.

RADIO-LOCATION

At the end of 1940 Air Marshal Sir Philip Joubert de la Ferté, Deputy Chief of the Air Staff appointed to solve the problem of night fighting, said in a broadcast that he looked forward to a time not far distant when German losses in night fighting would be proportionately as heavy as in daytime. He was attacked in a newspaper article headed, "You spoke too soon, Sir Philip". As I happened to know something of what was going on at the time, I steadily upheld his statement. So far as I can recall no other newspaper man did so, and I did my best to encourage our people by expressing my belief in what he had said.

During the first three months of 1941 his statement was proved to be right. In one night, during a heavy raid on London, 33 enemy raiders were shot down, nearly all of them by our fighters. At a moderate estimate that would be about 150 German machines destroyed altogether, as a certain number would necessarily be so badly damaged that they would sink while crossing the sea on the way home, others would crash in occupied territory soon after reaching the French or Belgian coast, and still others would crash on landing at their home aerodromes, or would be shot down by our "aerodrome-sitters", of which more will be said hereafter.

Round about the end of 1940 the Air Ministry in its communiques referred several times to what it called the "device" which was being used to enable the pilots of some of our night-fighters to get closely in contact with the German raiders. Naturally today the nature of that device cannot be divulged more than by saying that it is some form of ray, whether ultra-violet or infra-red is not disclosed. But about the middle of 1941 Mr. Power, the Canadian Air Minister, broadcast an appeal to young Canadians to join the Air Force and operate on ground radio sets which would locate the position of enemy aircraft. The Air Ministry thereupon released the information

that with these sets observers on the ground can pick up and follow the movements of enemy aircraft. Thus they are able to telephone to R.A.F. Fighter Stations who in turn radio instructions to the fighting machines about the precise position of the enemy.

Thus the British public was allowed to know that "radio-location", as it is called, is in fact a form of air scouting the result of which could be transmitted to the fighters. But naturally nothing was said about devices in the machines which enable the crew to communicate with radio on the ground. No doubt these devices have been communicated to the Army Air Corps and the Naval Air Service of the United States.

Not until the middle of 1941 was the fact made known that much of the execution done during the Battle of Britain over the English Channel was made possible by these radiolocators.

The official history says that before the war during exercises 30% detection of enemy bombers was satisfactory and 50% was very good. During the Battle of Britain the percentage rose to 75% and 95% and sometimes100%. The history says that the red-letter day for any group was on September 25 when in No. 11 Group 21 squadrons out of the 21 which were ordered up were able to report "Enemy sighted".

We were able to pick up the German machines as soon as they left the ground and got into the air over France many miles inland from the Channel, and were able to follow their track as they came towards England. Thus our fighter squadrons, although much smaller in number than the Germans, were always up in the air and ready to meet them and shoot them down in quantities before they reached the English coast. Thus we see that radio-location may be just as useful in daylight as at night.

Dr. Watson Watt, who developed the ray, was rewarded by being made a Companion of the Order of the Bath, the most senior of all English Orders.

ENGLAND HITS BACK

At the time of writing, August 1941, the position has been reversed. Our airplanes are now attacking the Germans heavily

over France, but our people are never met over the Channel by the German fighters. They have to penetrate 50 or 100 miles inland to find them.

Although we in this country see bombers and fighters passing overhead in excellent formation on their way to France and back, naturally I should not, if I could, give any indication of their numbers. A German account, with their usual fantastic exaggeration, mentioned recently that 200 British fighters had escorted 20 British bombers on a recent raid over Northern France. If we could afford such disproportionate escort for our daylight bombers as all that, then we must have a remarkable number of airplanes to spare. And in fact we obviously have large numbers.

About the end of 1940 Lord Beaverbrook, who was just retiring from the Ministry of Aircraft Production, while giving an account of his stewardship before passing to the higher sphere of Minister of State, announced the existence of the Hawker Typhoon single-seat monoplane fighter and of its Napier Sabre motor of 2,300 h.p. Naturally no particulars of this machine or its engine are available, but unofficially its speed is accepted as much more than 400 m.p.h. The engine is liquid cooled instead of being air cooled as have been the Napier H-type hitherto, and it was, when made public, the most powerful aeromotor in the world.

Lord Beaverbrook justifiably regarded putting the Typhoon into production as the crowning triumph of his administration of aircraft production. The airplane was designed about 1938 or 1939 by Sidney Camm and his design staff of the Hawker Co. and it was flying experimentally before war was declared. But, considering how long these things take to develop, Lord Beaverbrook was certainly entitled to credit for having got the machine out of the trial stage and having put it into production on a large scale without waiting for the squadron tests to which prototype airplanes are usually submitted.

Some months before this Sir Archibald Sinclair, Secretary of State for Air, had made known the existence of several new types of very big bombers; so perhaps I may be allowed, quite irrelevantly, to quote the remark, which by now has been re-

peated in America by American pilots who have seen the machines together, that the Boeing Flying Fortress looks "quite a little ship" beside our new big bombers.

News was also released by the Air Ministry of the existence of a very high-speed twin-motor fighter with two Rolls-Royce Merlins, known as the Westland Whirlwind, but no particulars of its shape, which is peculiar, or performance, were allowed. While doing its experimental flying before the war it was familiar to all the local yokels who called it the "Crikey", because of a familiar gasoline advertisement of the time showing a man with two heads looking right and left at the same time and ejaculating—"Crikey! That's Shell, that was."

The Air Ministry has also made known the existence of the Hawker Tornado, a single-seat fighter monoplane with a Rolls-Royce Vulture motor, also of very high power.

No particulars may be published about any of the other new British aircraft. But one can say rather more about the American fighters which are being sent over here in quantities.

AMERICAN COMBAT AIRPLANES OF 1941

To simplify things for our ordinary people who are flying and handling airplanes which are being sent over in such generous numbers for the Royal Navy and the Royal Air Force, names are being given to them instead of the complicated formula of letters and figures which U. S. airplanes have in their own country. Sometimes the American machines have names and in such cases they have generally kept them.

A catalogue of the American fighter types which were being delivered to England up to the Summer of 1941 will be of interest. The armament given is as designed in the United States. It may have been much modified to fit the requirements of modern air fighting. These machines, which are all monoplanes, are as follows:

(a) *The Bell Airacobra,* low-wing, 34-foot span, weight 6,150 lbs. loaded. One 1,100 h.p. Allison liquid-cooled motor. Top speed alleged 400 m.p.h. Ceiling 36,000 feet. Armament, one 37 mm. cannon gun, two synchronized machine guns

in the fuselage, and more machine guns in the wings. The lay-out of the machine has been described earlier in this treatise.

(b) *The Brewster Buffalo,* low-wing, 1,200 h.p. Wright Cyclone. Credited with 330 m.p.h. at 15,000 feet. Armament, two .5 machine guns in the fuselage firing through the air-screw with interruptor gears, and two .303 machine guns, one in each wing. This machine was designed and will be used as a Fleet Fighter.

(c) *The Curtiss P-40,* low-wing, known in the R.A.F. as the *Tomahawk.* With a 1,100 Allison its speed is given as 360 m.p.h. at 15,000 feet. Two synchronized .5 machine guns in the fuselage and four .303's in the wings.

(d) *The Curtiss Mohawk,* variety of the Hawk, 1,100 h.p. Pratt and Whitney Twin-Wasp. Speed is given as 323 m.p.h. at 15,000 feet and its ceiling as 36,000 feet. Two .5 synchronized machine guns in the fuselage and four .303's in the wings.

(e) *The Douglas Havoc,* a fighter version of the Boston night bomber. Two 1,050 h.p. Twin-Wasps or two double Cyclones of 1,500 h.p. each. With the latter its top speed is said to be 370 m.p.h.

(f) *The Grumman Martlet,* middle-wing, Twin-Wasp of 900 h.p. or Cyclone of 1,200 h.p. Speed is given as 330 m.p.h. at 19,000 feet, with a ceiling of 28,000 feet. Two synchronized machine guns in the fuselage and two in each wing. This, like the Buffalo, is designed as a Fleet Fighter.

(g) Although it does not appear officially as a fighter ordered for the R.A.F., I may mention here the *Grumman Sky-Rocket,* a twin-engine, single-seat, Fleet Fighter. It is one of the most curious machines yet designed, but interesting. Instead of having a long-nosed fuselage or nacelle sticking out between and in front of the engines, this has two radial engines fixed to the wings, and the nose of the fuselage ends abruptly somewhere about the level of the front spar between the engines. In fact the machine in all its photographs looks as if the wings and the two engines were trying to escape from the fuselage which is hanging on by its teeth, or nose, to the centre section of the wings.

It is an interesting idea because it presents to the air greater length of leading-edge in proportion to its total span than does any other type of airplane. The pilot is high enough up to see well forward over the leading edge in front of him and over the engines, and he is far enough back to see sideways and downwards behind the trailing edge. No particulars of its performance are available at present, but it looks very fast.

(h) *The Lockheed Lightning,* twin-motor, low-wing, two 1,100 h.p Allisons. Speed is given as 404 m.p.h. at 15,000 feet. Cruising range of 1,000 miles and a ceiling of 30,000 feet. Two .5 and two .3 machine guns and one 23 mm. Madsen cannon gun, all in the nose. It is alleged to be the fastest airplane in America.

(i) *The North American Mustang.* Beyond the fact that this machine is alleged to do better than 400 m.p.h., no details have been released at the time of writing.

(j) *The Republic Thunderbolt* (*XP-47B*), low-wing single-seat fighter, 2,000 h.p. Twin-Wasp. Reputed to do better than 400 m.p.h., and to be the fastest airplane in the world with a radial motor. (A notable feature is the four-blade Curtiss electric-controlled variable pitch air-screw.)

(k) *The Vultee Vanguard,* a low-wing monoplane with one 1,200 h.p. Twin-Wasp or Cyclone. Speed said to be 350 m.p.h. with a range of 1,158 miles. Ceiling 33,000 feet. Two synchronized .303 machine guns and two .5 machine guns in the fuselage, and two .303's in the wing. If that be true it is almost the most heavily armed single-seater in America.

That completes the list of American combat airplanes so far as has been made known in this country. Naturally one hears of faster fighters being built but equally naturally one would not, if one could, say anything about them in print until they had disclosed themselves on active service.

The following are dive bombers allocated to the R.A.F.:

The Curtiss Cleveland Helldiver (*77*), two-seat, single-bay biplane, all-metal. 850 h.p. Cyclone. Top speed 235 m.p.h.

The Vought-Sikorsky Chesapeake (*VS-156*), two-seat, low-wing. 750 h.p. Twin-Wasp Junior. Top speed 257 m.p.h.

The Brewster Bermuda (138), two-seat, low-wing 750 h.p. Cyclone. Top speed 302 m.p.h.

The Northrop, A17-A, two-seat, low-wing. 825 h.p. Twin-Wasp Junior. Top speed 225 m.p.h.

Another interesting type which may be included among combat airplanes is the North American NA-40C, or in U. S. Army Air Corps designation, B-25C. This is a mid-wing, five-seat, attack bomber in much the same category as the Douglas Havoc or our Beaufighter, but it is bigger than the Havoc. It has two Double-Row Cyclones, and is credited with a top speed of 310 m.p.h. and a range (at 256 m.p.h.) of 1,728 miles.

THE FLEET AIR ARM

One curious fact emerged about the beginning of 1941, namely the British Navy's lack of high-speed fighters. As everybody knew at the outbreak of war the Fleet Air Arm, which had been taken over by the Navy from the R.A.F. early in 1939, was equipped with Fairey Swordfish torpedo-bomber-reconnaissance biplanes and with Fairey Albacores, a revised version of the Swordfish. These are single-motor biplanes with fixed undercarriages and they have the appearance of genuine antiques. Actually, for biplanes, they are very good.

The Navy's only airplane which is primarily a fighter, the Fairey Fulmar, a low-wing monoplane with a Merlin motor, was evolved from the P4/34, which means that the original specification was issued by the Air Ministry in 1934. As such it was a good airplane. The Navy have likewise the Blackburn Skuas, already mentioned, primarily dive bombers, and the Blackburn Roc, which is a revised Skua.

But if a mass of high-speed Fleet fighters had been available in Norway, flown off heavily protected aircraft carriers a hundred miles out at sea, the result of that campaign might have been different. A couple of hundred first class fighters similarly flown off aircraft carriers heavily protected by destroyers a hundred miles off Crete might have saved that campaign, because they could then have kept the sky clear of German fighters, dive bombers, and troop carriers alike, whereas the German dive bombers could not have flown the distance from their

bases in Greece and in the Greek Islands to points 100 or more miles south of Crete, and have got back.

The longer range German bombers could have made the distance but, if the British aircraft carriers had been armed with fighters in the same class as the Spitfires and Hurricanes, they could have kept the bombers away and need only have been protected against submarines.

The need for Fleet fighters of the highest performance has also been felt by the Atlantic patrols. The big four-engine German bombers which go out on reconnaissance from Bordeaux round the west coast of Ireland to the extreme North of Norway and back, scouting for convoys and bombing individual ships, are sighted by carriers but are too fast for existing Fleet aircraft to climb up and catch them. At the time of writing we still have to see whether the Grummans and Brewsters are fast enough or have a quick enough climb for this work.

The policy of the U. S. Navy in using smaller carriers than those of the British Navy seems to have much to recommend it, because fighter forces at sea can be distributed in more different places, and there are, so to speak, fewer eggs in each basket.

GERMAN DEVELOPMENTS IN 1941

When the Germans found that their big bombers such as the Heinkel 111's and the Dorniers were being shot down by our night-fighters, they took to using the Messerschmitt 109 and 110, and Junkers 88, types which were originally fighters, as bombers.

I gather that they tied one bomb of 250 lb. or two of 110 lb. or so under the fuselage of a single-motor Me-109, which was just able to stagger off the ground with it. When once they were off the ground the Me-109's could climb quite well with the load, and climbing steadily from France towards England they were quite high when they reached their objective. Then they screeched down at a colossal speed which made them difficult for our fighters to catch and for the anti-aircraft guns to hit, and even for the searchlights to follow. But although they scored to a certain extent, they were shot down by our heavily armed night-fighters.

A flying officer of one of the occupied countries, who is now flying in the Allied International Air Force, after having escaped from his native land, told me that the Germans overload the two-motor Me-110's and the Junkers 88's shockingly. He said that to see them just staggering off the end of a very long runway was painful to watch and was sheer cruelty to aircraft. He added that the failure of one engine in the take-off or the failure of the machine to lift before it got to the end of the run invariably meant a crash, and generally a burn-up and the death of the whole crew.

Much has been discovered about German fighters during 1940-41. Those which were shot down during the Battle of Britain were mostly of types which were already well-known, such as the Me-109, A, B, C, and D, but the Air Ministry Department which exists to discover as much as it can about the enemy's shot-down airplanes naturally does not want the Germans to know how much we know about their newest types.

The last Messerschmitt of which any information was available is the Me-109 F2. It is similar to all the others but has a rather bigger span of wing and certain alterations in the engine which are intended to give it a much higher ceiling from which to dive on our new high-level bombers. It seems to be able to get to 40,000 feet all right but only by the sacrifice of speed at reasonable levels in the region of 25,000 feet; and even at that height it is not particularly manoeuvrable. Consequently the British pilots think less of it as an opponent than they do of the other 109's.

The number of bombs carried by the Messerschmitts as night-bombers seems to have varied. A 250 lb. bomb, as already mentioned, seems to have been the original idea, but investigation of crashed machines show that they only carried one 50 kg. bomb (about 110 lb.), which hardly seems worth while. These machines were fitted with a bomb sight which could be used at a diving angle of 45°.

Experiments also show that the high-level diving speed of the Me-109 is about 406 m.p.h. and that the terminal diving speed is only 446 m.p.h. This seems to be limited by the fact

that at that speed the engine would be doing 3,000 r.p.m., a rate which it is not supposed to exceed for more than one minute.

Seeing that the world's speed record by a specially tuned Messerschmitt is 480 m.p.h. following a power-dive, 446 m.p.h. does not seem much, but we must remember that the sawed-off wings of a record breaker will stand a bigger jerk when pulling out of a dive than will the normal wings of a fighting machine.

The Me-110 twin-engine fighter, a low-wing cantilever monoplane, does not seem to have been so successful as was expected. It was already flying before the war and was then much admired. Its top speed at 16,500 feet is about 365 m.p.h. with two Daimler-Benz motors. It carries two 20 mm. Oerlikon shell-firing guns under the nose, four 7.7 mm. (.303 inch) Rheinmetall machine guns in the upper part of the nose and only one manoeuvrable gun aft. They may vary in armament as time and experience demands.

The speed of the machine at service ceiling is said to be about 355 m.p.h. and the maximum diving speed 435 m.p.h.

A variant of the 110 is the Jaguar which was produced as a long range fighter-bomber. It carried three 20 mm. cannon guns and two 7.7 mm. machine guns. There is also a story that some of these machines had been fitted with two additional cannon guns, one firing through the hub of each air-screw.

All the early Messerschmitts had Handley Page (or Lachmann) slots all the way along the wings, but some of them only have slots at the wing tips, to give added control to the ailerons at low-speeds. The latest also has a trailing edge flap to reduce its landing speed.

The Daimler-Benz twelve-cylinder, inverted-Vee, liquid cooled, engine, which started by being about 1,100 h.p. in the earlier Messerschmitt fighters, was giving 1,500 h.p., but probably more by the middle of 1941.

Dr. Heinkel's fighters must have been rather disappointing to the Germans. The He-112 which was to have been his reply to the Me-109 turned out to have some defect which has not been made known in this country. It is said to be quite fast but appears to be bad in manoeuvres. Consequently the later types have only carried one gun in each wing outside the

radius of the air-screw and had two guns in the fuselage firing through interruptors, and one cannon gun firing through the boss of the air-screw.

Junkers produced the Ju-88, a twin-engine bomber-fighter with two 1,200 h.p. Junkers Jumo 211-B motors. Its top speed is only about 310 m.p.h. so its weapon value is not so high as its designers had hoped.

The later German machines, bombers and fighters alike, carry heavy armour. This naturally has made necessary the fitting of heavier guns and the development of heavier shells in our cannon guns.

R. A. F. SUPERIORITY

One fact has clearly emerged from the general lack of information on all sides about what is going on, namely that British airplanes, engines, armament and armour remain steadily ahead of those of the Germans. We have been short of each or all of them, just as we have been short at one time of pilots, another of navigators, and another of gunners, but that is simply because we started late.

Of the Italian airplanes in 1939-40 there is little to be said. A popular notion is that because some of them are built largely of plywood and not of sheet duralumin throughout, they must necessarily be inferior. In fact wooden airplanes have a lot to recommend them. Stories of wooden airplanes being set on fire by incendiary bullets and shells is nonsense. Actually if the gasoline in a wooden airplane is set on fire it probably burns up plywood quicker than duralumin, but either way the pilot either bales out and is saved or stays in and is killed. Against short fires, such as blaze up and are put out quickly with a fire extinguisher, wooden structure made of fire-proof timber is quite good.

The trouble about Italian airplanes is they have not enough power nor enough pilots. The whole *Regia Aeronautica* was too small to put up a serious fight against our R.A.F. But individual pilots fought well, and although the Italians were beaten whenever they appeared, over the English Channel or over Libya, they were not disgraced.

At this time of writing nothing definite can be said about either the equipment or the personnel of the Russian Air Force. But there seems no doubt that by sheer weight of numbers the Russian combat airplanes are doing considerable execution against the German Luftwaffe.

At the time of writing one can safely say that on the European Front the British combat airplanes have consistently been superior to German planes in performance and armament, and have been better flown.

Judging by Air Ministry communiques the Middle East Command seems to be getting a lot of American-built fighters which are apparently shipped . . . (censored) . . . from the U. S. and are then flown in stages of a few hundred miles . . . (censored) . . . to Cairo . . . (censored) . . . By all accounts the American fighters which have been in use in the Middle East have done well, not only against the Germans and Italians but against the small amount of air resistance which has been shown by the Vichy forces in Syria.

THE BRISTOL BEAUFIGHTER

The last British combat airplane about which the Air Ministry had released information when the last lines of this treatise were being written is the Bristol Beaufighter. The name of the aircraft has been mentioned in communiques quite often, during the past two or three months, but nothing has been said about it.

At the beginning of August the Press was allowed to announce that the Beaufighter is a twin-motor two-seater which has a span of about 58 feet. Its engines .... (censored) .... are two Bristol Hercules, two-row, sleeve-valve radials of about 1,000 h.p. each. But there is no reason why engines with still higher power should not be fitted to make it still faster.

Its speed is given at something more than 330 m.p.h. Probably the Germans know how much more, from bitter experience. It carries gasoline for 1,500 miles, which, allowing it a cruising speed of 250 m.p.h. means six hours' cruising, or say a range of 500 miles out, more than an hour's flying at fighting speed, and 500 cruising home. That makes it a very formidable long

range fighter. And of course it could extend its range considerably if it were held down to one hour's fighting. An adequate supply of such machines might have saved the situation in Norway or in Crete.

The Beaufighter weighs 10 tons in fighting array, and therefore must carry a goodly supply of ammunition for its many guns. These are four cannon guns, presumably of the standard 20 mm. bore, and with them are six ordinary machine guns of .303 bore. But here, as with the engines, there is no difficulty about fitting bigger guns such as the 37 mm. cannon as made in the States, or the 40 mm. cannon as made in Germany.

In fact the Beaufighter is a sister machine to the Beaufort Torpedo-Bomber. Much of the same material is used in the two machines, which is a commendable economy. Herein congratulations are due to Messrs. Pollock & Frise on whom has fallen the mantle of the late Frank Barnwell, designer of the Blenheim, which has done so well in this war, and of the immortal Bristol Fighter.

The Beaufighter made its name first as a night-fighter . . . . (censored) . . . . But more recently it has done excellent work as a day fighter. It took part in the heavy raids on aerodromes in Sicily at the end of July, which meant that the Beaufighters had to fly all the way from Egypt. And it has done shattering work in sweeps over France.

And this, so far as I can discover, covers the evolution of combat airplanes from their earliest days up to the present time.

Part IV

ARMAMENT AND ARMOUR

A brief chapter on armament in relation to the airplanes on which it has been used seems advisable. Some of it may be a recapitulation of what appears earlier in this treatise, but that will serve to get the picture in the right perspective.

The first use of armament in airplanes was the firing of a gun or two, probably Lewis guns, between the feet of passengers on Wright biplanes in the United States.

In 1912 Mr. Lewis brought samples of his guns to England. A bucket seat was rigged among the struts of the undercarriage of a box-kite biplane, with a gun swivel in front of it. Marcus Manton sat in that dangerous perch, underneath the pilot, the well known Claude Grahame-White, and fired a tray of cartridges over the British Army rifle ranges at Bisley near Aldershot. That was the first machine gun fired from an aeroplane in Europe.

In 1913 a Naval Officer, Lieutenant Robert Clark-Hall, practised firing, while flying, a two-pounder Naval quick-firer from the nose of a Short pusher biplane of the Naval Air Service. He and his pilot and the airplane survived, but the recoil was judged to be too dangerous for general use.

In 1914 Vickers Limited fitted a Vickers gun, with belt feed, in the nose of a pusher biplane built by their aircraft factory at Brooklands Motor Track. None of these went to France at the start of the war.

Also in 1914 the French tried out some *mitrailleuses* in Farman and Voisin pusher box-kites.

In actual war the first weapon used to bring down a German airplane was a revolver fired by Lieutenant Vesey Holt, R.F.C. The German pilot was not hurt but much frightened, and descended and was captured.

In the early months of the war observers in tractor biplanes carried service rifles, sitting in front of their pilots, and fired as best they could outside the circle swept by the air-screw, or sideways through the struts and wires, or backwards past the pilots' ears.

In pusher biplanes they carried their rifles across their knees and fired as and when chance offered.

The Germans in tractor monoplanes of the *Taube,* or pigeon, type were little better off because of the masts and stay wires on top of the wings.

In 1915 Roland Garros fitted steel plates to the blades of his air-screw, which deflected the bullets which would have hit and probably broken the blades.

Soon afterwards Anthony Fokker designed an interruptor gear driven from the air-screw shaft which stopped the gun from firing when a blade was in front of the gun muzzle. This revolutionized air attack.

In England the Australian Kauper, working with the Sopwith Co., designed an interruptor gear. The Roumanian Constantinesco designed a synchronizing gear which fired the gun when no blade was in front of the muzzle.[8]

In the United States Carl Gustav Swebilius designed a similar gear. He is now head of the High Standard Mfg. Co. of New Haven, Connecticut, making .5 Brownings for the R.A.F.

Also in 1915 Mr. Scarff, a Warrant Officer in the British Navy, designed for the Royal Naval Air Service a mounting for the Lewis gun consisting of a ring, fitted behind the pilot of a tractor biplane, in which the gunner stood. He could run his gun all round the ring and elevate or depress it to an extent limited only by the structure of the airplane, and check gear to stop him from shooting his own tail off. Thus he covered practically a hemisphere of sky, except that he could not shoot directly below him.

Vickers belt-fed guns were used with the synchronizing or interruptor gear in front. Lewis guns were used on the Scarff rings aft, or on Scarff rings in the noses of pusher biplanes. The geared guns were fixed and were aimed by manoeuvring the airplane to suit.

Plain ring and bead sights were used at first. Later the Aldis telescopic sight was made standard.

Whether Vickers belt-fed or Lewis drum-fed the guns of the War 1914-18 fired at a rate of about 600 to 800 shots per

[8] See Note 1, page 7.—Ed.

minute. At first the Vickers belts were of fabric in which clips to hold the cartridges were riveted. Later the clips were designed to link to one another and form a chain, each link flying off into space as its cartridge was fired. As the links sometimes stuck in the tail control hinges and jammed them, or flew back and tore the fabric covering, chutes were devised to throw them out clear of the fuselage, or into bags which retained them.

Some single-seat biplanes were fitted with Lewis guns hinged on the aft spar above the cockpit so that the pilot could fire upwards if he could get into position under the unprotected belly of an enemy. They slowed the machines too much.

Single-seat pusher biplanes had a Lewis gun on a swivel in front of the pilot. He could lock the swivel and aim the machine, or use the gun loose to fire at an angle to his course.

By 1916 or early 1917 we had progressed to fitting twin Lewis guns on the Scarff rings, aft in a tractor or forward in a pusher. Both guns fired by Bowden wires from a single trigger. A little later twin guns, one on each side of the engine, were fitted to the front of most fighters.

In 1918 the Hispano-Suiza aero-motor firm built a Vee-type engine in which the cam-shaft, which lay between the cylinder blocks, was enlarged so that it carried the air-screw (thus running at half the speed of the engine) and was bored out so that the shells of a 20 millimetre "cannon" could pass through it. This was known as the *"moteur-canon"*. Only a few were built, but they did well, and if the war had gone on they would have been largely used.

In 1918, too late to be used in the war, Dr. Junkers built an all-metal biplane which carried 16 guns inside, pointing forward and downward so that they delivered a raking fire on troops on the ground. A man inside loaded the guns, which the pilot could fire 4, 8, 12 or 16 at a time as seemed best.

After the War 1914-18 little was done for some years to improve armament. There were more machine guns of rifle calibre around than all the nations could begin to use, in spite of "colonial" wars in the British Empire and the French Empire and the work of the U. S. Marine Corps in Nicaragua.

Also little was done to armour airplanes. A few machines in the War of 1914-18 had armour plate seats fitted surreptitiously by their owners. And late in the war the Sopwith Co. produced a ground strafer biplane which had an armoured bottom. Dr. Junkers also armoured the bottom of his sixteen-gun ground strafer.

In the years between 1930 and 1940 the armament firms began to sit up and take notice. The growth of the U. S. Naval Air Service, and to a less degree of the U. S. Army Air Corps, stimulated competition.

The great Browning firm, whose name was made best known to the world at large by the Browning automatic pistol, worked up the rate of fire of their rifle-calibre machine guns. At the same time their old rivals, the Colt, whose .45 six shooter was already a Wild West legend, took a lively interest in the game.

At the start of the war in 1939 Browning had most of the trade in this country, with a .303 gun which fired at 1,200 shots per minute. We had then hardly heard of the .5 Colt gun, which seemingly was developed by and for the U. S. air services. But we had heard a lot of the 37 mm. air cannon developed by the American Armament Corp., and shown to European air forces at the Brussels Aero Show only a few weeks before the war.

In Europe most interest was centred on the 20 mm. shell-firing cannons, which were being built by various firms, such as the Swiss Oerlikon, as well as the regular machine gun makers in Germany, France, England and Italy. The 20 mm., or .8 inch, cannon had done a lot of work in the Spanish Civil War. It had not been fitted to the front of fighters, except to a few which had the Hispano-Suiza *moteur-canon*. But it was used in the Italian-built Spanish-flown Savoia-Marchetti bombers, both on top and firing down through the floor.

These bombers after dropping their bombs used to go looking for Red transport columns on the roads, and beat them up with cannon shells. I have been told that these shells were also effective against small transport ships at sea. But with the cases then used they were not penetrative enough to put tanks out of action.

The surprise, to the enemy at any rate, in the early days of the war, was the terrific success of the British eight-gun fighters. Four guns were carried in each wing, and they fired *outside* the air-screw disc. Therefore there was no slowing down of the rate of fire by interruptor or synchronizing gear. Every shot had free passage.

The fire power was, and is, terrific. Firing 1,200 shots per minute from eight guns means a rate of 9,600 per minute, or *160 per second.* The initial velocity of the bullets is far higher than those from the 1914-18 guns and so they hit harder. But even if they did not, the mere weight of 160 bullets per second would be considerable.

For that reason one can understand that short range combat airplanes which only carry gas for 2½ or 3 hours flying can only carry ammunition for two or three minutes' firing. After all, few men would care to carry 28,800 rounds of rifle ammunition very far.

In the eight-gun outfits the pilots can fire the guns 2, 4, 6 or 8 at a time as they think best. But as a rule the most deadly pilots give one burst of perhaps two or three seconds and then stop. If they do not get their victim in that time they are not likely to keep him in their sights much longer.

There is a story of two gunnery experts discussing a new gun sight. One suggested that they should get the opinion of a big tough Australian pilot who was in the mess. So they asked him what he thought of the So-and-So Sight. His answer was: "Sights? Sights!! I never use 'em. I just fly up the other feller's tail, press the buttons, and fly through the bits".

One reads of German fighters disintegrating in the air when hit. Apparently it happens quite easily when in one second 160 bullets hit in one spot. As a fighter pilot said to me, on this subject, "You know, a self-sealing petrol tank does not keep a wing really firmly in position after the spar has been sawn through by a bunch of 160 or so machine gun bullets hitting it in one place."

And these new guns seldom jam. In 1914-18 pilots and gunners had to learn about sixteen ways of clearing jams, hardly any of which were possible in the air, even by a gunner

in a Scarff Ring who had both hands free, and never by a pilot who had to keep one hand on his stick. Most pilots of single-seaters used to carry a 2 lb. fitting hammer in a sling in the cockpit. If a gun jammed they hit it hard on the butt with the hammer. If the jolt did not clear the jam they went home.

In the modern single-seaters the guns are out of reach of the pilot anyway. And if one or two jam out of eight they do not matter a whole lot.

Today there is much argument between those who favor the high rate of fire of the 1,200 shot-per-minute .303 Browning and those who prefer the slower rate of fire but higher muzzle velocity, and so higher penetration, of the .5, whether Browning or Colt. There are even those who would prefer a solid bullet in the .8 inch (or 20 mm.) cannon gun, because they believe that the smashing power of a .8 bullet would be so much greater than that of the .5, or of a number of .303's, and cannon shell of 20 mm. do not do much damage unless they burst inside and in contact with something.

If the 20 mm. hits a man in the body or a limb he is as good as dead, but if it bursts within a foot or two of him after hitting the metal skin of an aeroplane it is hardly likely to harm him, unless a splinter gets him in the eye. The splinters of a 20 mm. cannon shell are rather like clippings off toenails made of iron.

I have seen a bomber come in, with the gunner dead, hit in the chest by a 20 mm. shell, the pilot and navigator just scratched by 20 mm. shell splinters and the radio man unhurt although a cannon shell had burst a few feet in front of his face. One cannon shell had ripped open an intake pipe of one cylinder, exposing the valve stem, without stopping the engine. Another had burst up against an elevator control tube and flattened it without breaking it. But what nearly wrecked the machine on landing was the fact that one wing flap had been riveted to the trailing edge of the wing by a couple of ordinary .303 bullets which punched the metal from the holes in the wing into the corresponding holes in the flap so that it could not slide. The flap under the other wing did slide out, and the machine started to do a slow roll. Fortunately the working flap retracted and the pilot got the machine down level, but the under-

carriage had been shot up, and collapsed. So there was rather a heap on the ground—but, barring the poor dead gunner, nobody was much the worse, although the machine looked like the top of a pepperpot.

Since those days armament has gone up. Most combat airplanes seem to carry .5 guns instead of .303 rifle-calibre guns. Also, without giving away secrets, but quoting only the combat reports of pilots published in Air Ministry Communiques, we find that apparently most modern fighters—that is to say the "hotted-up" . . . . censored . . . . Spitfires with more powerful engines—carry cannon guns as well as machine guns.

GUN TURRETS

One of the most remarkable steps in armament has been the power driven gun turrets.These are a purely British development—in fact one might say that they are Scottish, seeing that the inventor and designer of the most successful type is Captain Archie Frazer-Nash. His turrets, which are hydraulically driven, are mostly used in big bombers such as the Whitley and Wellington, but they are also used in some bomber-fighters. Another type, which is used in the Defiants and Rocs, is the Boulton-Paul, which is electrically driven. The Bristol Co. have a design of their own in the Blenheims, Beauforts and Beaufighters.

One or other of these types is used in the giant bombers, the Short Stirlings, Handley Page Halifaxes, and Avro Manchesters, and still newer types, but naturally no detailed information may be given. Some have been fitted to certain American machines which have been delivered here. And American-built versions of these turrets will be fitted to many American machines in future.

The gun turrets are successful because they upset a pseudo-scientific theory. The Herr Doktor Magnus proved mathematically at great length what all gunnery folk knew by experience, that if you fire a bullet or a shell across a strong wind it will spin upward if the wind is on one side and downward if the wind is on the other side. Consequently a bullet from a machine gun fired broadside on from a fast aeroplane would

have an enormous upward deflection on one side and an equally enormous downward deflection on the other. And the faster the aeroplane the greater the deflection.

As the deflection varies with the speed at which the bullet is travelling sideways through the air, and with the angle at which it is travelling between a full right angle in a true broadside and no angle if fired dead aft or forward, the making of gun sights to work in such infinitely variable conditions seemed impossible.

Furthermore, at Cazeau, in the foothills of the Pyrenees, in the South of France, where was the Air Gunnery Experimental Establishment of the French *Armeé de l'Air,* somebody started a theory, or perhaps just a story, that at certain air speeds, varying with the speed of the aeroplane and the muzzle velocity of the bullet, and the angle to the air, a bullet would tumble end-over-end, lose its sense of direction and become completely mad.

What with the "Magnus Effect" and the "Cazeau Effect", as they were called by the bogus, pseudo-scientific theorists of air ballistics, the notion of aiming a gun broadside from an aeroplane seemed fairly hopeless. But what worried the gunners was not the aiming, but how to hold their guns at right angles, or anywhere near it, to a blast of 200 m.p.h. or so—which had to be done if one wanted to get a shot from the aft gun pit of a diving two-seat fighter at an enemy fighter attacking from the beam or wide on the quarter.

The first Frazer-Nash turrets, small two-gun affairs, were first tried out in Hawker Harts, as mentioned earlier in this work. Their feature was that the gunner revolved with the turret—seat, guns, ammunition and all.

In the Scarff ring, the gunner moved himself round by the action of his feet, and slid the gun round the ring, and locked it in position with a hand catch, and then moved the gun up or down or sideways on a swivel when aiming. In the turret he keeps his thumbs on the firing buttons, and, with his hands and feet on the controls, moves the whole apparatus, through its hydraulic gear, so that he can keep his eye on his target through the sights.

I believe that ingenious persons have designed sights with wind vanes and things which are supposed to work in these

strange conditions, but my air gunner friends tell me that their ammunition belts are loaded with tracer bullets and incendiaries and solid bullets in certain proportions, and that they aim their guns by observing the trail of the tracers, just as one aims a hose by observing the fall of the water. And, with guns firing at 1,200 shots per minute, aiming is not so difficult, despite Dr. Magnus and Messieurs of Cazeau.

The first authentic fighter to be fitted with a four-gun turret was the Boulton-Paul Defiant (mentioned in a previous section). It introduced a new tactic in air fighting.

Hitherto tactics had been much as in 1914-18, except that a dive on an enemy takes 10,000 feet at 500 m.p.h. instead of 1,000 feet at 100 m.p.h. Also loops or vertically banked turns have a radius of perhaps half a mile instead of a couple of hundred feet. Diving below an enemy and zooming up to shoot his machine in the belly is still done by the best people. And, as already quoted, the technique of the real killer is to go for the enemy's tail and blow it off.

Clever pilots will discover an enemy's "blind spots", where his fire is blanketed by his tail, or limited by the angles through which his guns can travel. But otherwise there is nothing essentially new so long as combat airplanes have their guns firing forward, whether the eight rifle-calibre guns of the old Hurricanes or the 37 mm. cannon and .5 Colts of Mr. Lawrence Bell's Airacobra.

But the Defiants were different. They were built to demonstrate a new principle. Hitherto the pilot had been the captain of the ship, and the aft gunner was there only to keep enemies off his tail. Sometimes a democratic crew worked together in perfect unison and got wonderful results when the pilot manoeuvred to give his gunner a chance. In the Defiant, the gunner, with four guns in an electrically driven turret, was the skipper of the ship, and the pilot, who had no guns in front, was there to put him where he wanted to be.

Against the Junkers Stuka dive bombers the Defiant was deadly. A Stuka, when its pilot has its nose on the target is as immobile laterally as is a hen with its beak on a chalk line. A fighter diving on its tail is met by a gunner sitting behind the

pilot. A beam attack on a diving Stuka is not easy, but the Defiants, which were suddenly let loose during the retreat to Dunkirk, came in wide of the angle of fire of the Stuka gunner, closed in laterally, diving almost parallel with and close to it, and then, when right alongside in close formation, the Defiant gunner used to open up with his fire-spitting hose of tracers, and his four guns just blew the guts out of the Stuka.

Later in 1940, and early in 1941, the Defiant became too slow for daylight fighting against the rearmed Messerschmitt squadrons, so it was turned over to night-fighting, for which it was originally designed, and at that it has also been highly successful . . . . censored . . . .

When Mr. Power, the Canadian Minister, called for Canadian volunteers to sit on the ground with a radio set and locate the enemy some people thought that he had said too much. But he really told nothing that matters. The radio locators only keep track of enemy machines and let the fighters know where they are. The last little bit, whether in miles or yards is not for me to say, is the affair of the fighters.

Up to the summer of 1940 the best results were got on moonlight nights, because the light gave the pilots just that extra help which direct sight gives . . . . censored . . . .

We cannot claim to have night sight all to ourselves. The Germans were boasting about their *Wolkenrontger* before the Air Ministry mentioned "the device" and long before Mr. Power in Canada broadcast the demand for radio-location operators.

"Wolken" (English "Welkin") means "clouds" and Dr. Rontgen discovered X rays, so we may translate the name into "cloud piercer", only the Welkin which rings, in song and story, means the heavens in general so we may assume that the *Wolkenrontger* is a sort of television apparatus which sees in the dark with infra or ultra red or violet rays. Anyhow, the Germans say that they can pick up gun positions with it at night. So far the R.A.F. seems to have done most to "make the Welkin ring".

In this war almost anything is more than likely to happen, so I am neither believing nor denying the German story. We may come to telepathic thought transference or power transmission

by radio. A few years ago the most credulous would not have believed the things which are happening regularly today. And now that we have seen how the mutual peril of a few bombs have got scientists working together in a huddle and forgetting their professional jealousies and personal animosities, there is hope of real scientific progress.

War certainly energizes scientific research. But it is an expensive way of generating the needed energy. It reminds one of Charles Lamb's essay describing how the Chinese habitually set fire to a house to set fire to a pig sty to get roast pork, because roast pork had been discovered accidentally by that process.

ARMOUR

Nothing shows the enormous progress in the design of airplanes and engines more than does the amount of arms, ammunition and armour which they carry. To deflect modern high-velocity bullets of rifle calibre, let alone .5 inch solids, and armour-piercing cannon shell, armour has not only to be tough but thick. And both the Germans and ourselves seem to have got it. In fact over the more vital spots the armour will stand direct hits.

Naturally I cannot, and would not if I could, describe the defensive armour in our own aircraft, but I can say that in practice it has been proved to be better than the German armour when tested against our own guns, which are just a bit better than the German guns.

The Germans seem to trust to the engine to protect the pilot from shots fired from dead ahead. Presumably they would rather have an engine put out of action by a head-on attack than ask it to carry the extra armour to protect it *and* the pilot. But there is armour plate under the pilot's seat to protect him against the various forms of attack from below.

Also, the armour comes up behind him to the width of his shoulders and then tapers to his head, where it curls over the top of his head and protects him against plunging or diving attacks from above.

To protect him in front above the level of the engine the pilot has a multiplex glass screen, made of the old-fashioned

glass and celluloid in alternate layers, not the new safety glass which stands up to a lot but, when hit hard enough, flies into uncountable bits, generally of octagon shape and about the size of a good hailstone.

I imagine that these multiplex glass screens were originated by Chicago gangsters for their armoured saloon cars. They seem to be impenetrable by rifle-calibre bullets but are liable, seemingly, to become impenetrable by human eyes, hence the development of periscopic sights which enable pilots to see round their windscreens.

Probably this use of heavy armour accounts for the fact that so many German pilots escape death by bailing out with their parachutes after their airplanes have been broken to pieces by the fire power of the R.A.F. fighters.

When the pilot is hit the machine goes down, generally in an obviously uncontrolled spin, but anyhow in one piece. But in these days more commonly the whole tail unit is blown off by the sawing action of 160 bullets per second plowing into the fuselage where the cross section is smallest; or else a wing tip is blown off; or a wing breaks off at the root because the concentrated fire has sawn through one of the spars at the root.

NEW GERMAN ARMAMENT

Lately that department of the Air Ministry which dissects crashed or forced-landed German aeroplanes has let out some interesting facts about the armament of the new Messerschmitt 109F. fighters. The Air Ministry rightly keeps a lot of such information to itself, because we do not want the Germans to know how much we know about them. But, obviously, speed, climb and manoeuvrability being equal and pilots about equally skilful, the better-armed machine has the greater value as a weapon.

As already mentioned, our Hurricanes and Spitfires which won the Battle of Britain a year ago carried eight rifle-calibre (.303 inch, or 7.7 mm.) machine guns apiece, each gun firing at the rate of 1200 rounds per minute, or 9,600 bullets per machine per minute or 160 bullets per second, which meant about 270 lbs. of projectiles per minute.

Our gallant Parliamentary Under-Secretary of State for Air, Captain Harold Balfour, M.C., a fighter pilot of the last war, who himself had flown all our latest fighters, had already stated at the time of the Battle of Britain that we had tried out our new cannon guns and found them good.

The Air Ministry has allowed publication of the fact that the latest Spitfire V (for Five or Victory as you please, a happy coincidence) carries two cannon guns and four machine guns. The rate of fire of the cannon is necessarily much slower than that of the machine guns but they fire a heavy shell; so allowing, modestly, that our cannon are as good as those in German machines, which seem to have a rate of fire of about 100 shells per minute, that gives our machine a rate of 4,800 machine gun bullets and 200 shells per minute—a combined weight of roughly 240 lb. per minute.

Note that this is *a rate of fire,* for no short range fighter can carry ammunition for more than 3 minutes non-stop firing. And if it fired for more than a few seconds at a time it would burn out the rifling in its gun barrels.

The early Messerschmitts had two cannon and two machine guns which combined had a rate of about 1400 rounds per minute. The cannon fired outside the air-screw disc and the machine guns fired through it, with interruptor gear. The next type had one cannon which fired through the air-screw shaft, and two synchronized machine guns in the fuselage. This meant about 600 rounds per minute from each of the machine guns, leaving 200 rounds per minute for the cannon guns, so that combined they still had a rate of 1,400 rounds per minute, and a weight of roughly 125 lbs.—less than half that of our fighters. But the longer range and hitting power of their cannon gave them an advantage, when their pilots were clever enough to catch ours in a bad position.

Now the Germans have a new cannon gun of 15 mm. (.591 inch) bore, made by the Mauser firm, famous for their rifles and automatic pistols. This is said to fire at a rate between 800 and 1,000 shells per minute. The shells are said to weigh three ounces each, and as their single-seat fighters can only carry shells for less than a quarter of a minute's firing, their special

weapon-value does not last long. Those new guns would be more dangerous if used in long range multi-motor fighter-bombers, which could carry more ammunition.

The newest Messerschmitts carry only one of these Mauser cannon. They have also two machine guns which are fired by interruptor gears between the blades of the air-screw, and therefore cannot well fire faster than 600 shots per minute. Nevertheless, firing thus only something over 2000 shots per minute, the weight of metal fired, thanks to the Mauser shooting through the air-screw shaft, is something between 750 and 800 lb. per minute (at a rate of, remember).

Against our manoeuvrable, and well flown, Spitfires and Hurricanes this new weapon has not proved highly effective, but against even well armed and armoured bombers it is a danger to be met and beaten, for these Messerschmitt 109's are designed specially for high flying to reach our Halifaxes and Stirlings and Boeings (commonly called "Flying Fortresses") away up at 30,000 feet or more.

If, in spite of our Frazer-Nash gun turrets, which originally carried four .303 machine guns but can obviously be made to carry heavier guns, these high-level German fighters should prove effective up to the 40,000 feet which we know they can reach, the old controversy between the advocates of big and little bombers may be revived.

Mr. Lawrence Bell, who builds the American Airacobra, which carries a 37 millimetre (1½ inch) cannon, and six machine guns (some American accounts say twelve, which seems unlikely) told me before the war that he had said to General Arnold, Chief of the U. S. Army Air Corps, that the more Flying Fortresses he put into the air the more targets he was providing for Bell Airacobras, and their like.

In Germany, when General Ernst Udet, himself a fighter pilot, was made technical chief of the Luftwaffe, he almost stopped the production of the huge Focke-Wulf and Junkers and Blohm-and-Voss four-motor bombers, and offered to sell them to the world as airliners. Today they are used for Atlantic patrols between Brest and Norway, but they have not been used much for bombing England. In the big blitz on London in

September the smaller and faster twin-motor Messerschmitts and Junkers were mostly used, and single-seat fighters carrying only one bomb.

GUNS

A serious disquisition on guns would take up too much room in this treatise but we may review briefly the bore, or calibres, of the guns used. Remember that roughly an inch is 25 millimetres.

The biggest gun appears to be the German 40 mm. Mauser cannon. That means a trifle more than 1½ inch.

Next is the 37 mm. cannon gun made by the American Armament Co. as near as no matter 1½ inch.

Then there is the 20 mm. cannon gun, made by several British and American firms, by the Swiss Oerlikon, by the Hispano-Suiza firm, and by various German firms.

An odd size is the 15 mm. (.591 inch) semi-cannon used by the Germans in the Messerschmitt 109F. They seem to use a solid armour-piercing tracer alternately with explosive shells. But the explosion of so small a shell does not seem much more dangerous than would be the expansion of a hollow nose, or dum-dum bullet. The 15 mm. shell may have value as an incendiary.

After that come the small arms proper.

The Italians use a 12.7 mm. (or ½ inch, or .5 inch) machine gun, for which they load their belts, as a general rule, (1) armour-piercer, (2) explosive (hollow-nose) incendiary, (3) tracer, (4) armour-piercing incendiary, (5) plain incendiary.

The Americans and British use the .5, in various forms, made by Colt and Browning and by Vickers, and other British firms.

All nations have then standard rifle-calibre guns—Vickers, B.S.A., Lewis, Colt, Browning, Madsen, Oerlikon, and so forth. But they vary somewhat in bore. The German is a 7.92 mm., the Italian is 7.7 mm., as is the French; the English is .303 inch, which is the same thing as nearly as may be, and I believe the American guns are the same.

WEAPON-VALUE

A new measure of an individual airplane is contained in the expression "weapon value". In considering the qualities of a new type its value as a weapon must be considered, and those who are to direct its strategic or tactical use ought to consider its weapon value for their purpose.

For example a pursuit ship must above all be fast and pack plenty of fire power. If anything has to be sacrificed it may do with less manoeuvrability and shorter range. But a combat airplane which is intended for defense against enemy bombers or fighters must, above all have a high rate of climb and a high ceiling, and must be very manoeuvrable because it must climb high to get above the enemy, it must get there quickly, and it must be handleable in a diving attack. It must have the guns, but it can sacrifice speed, because it can get what speed it wants by diving.

Long range fighters *must* sacrifice manoeuvrability to range and ammunition load. Ground attack machines must sacrifice speed and range to ammunition and more and more guns. And so each type designed or equipped for a special purpose must be considered on its weapon-value for that job. I recommend that those who are now designing, building, or using aircraft, and those who hope to do so in the future, always keep their eyes on the weapon-value of combat airplanes.

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